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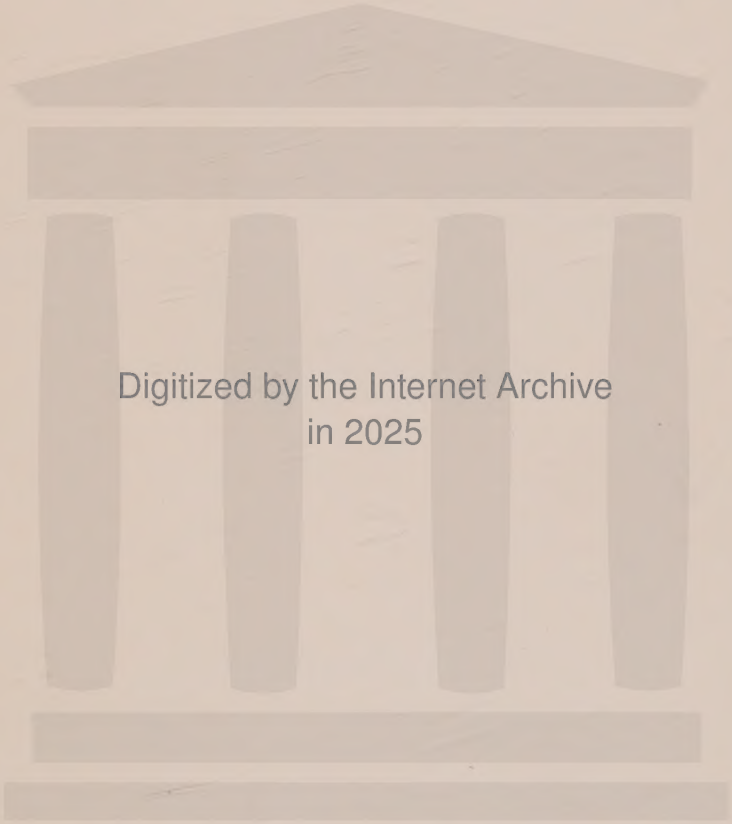
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A TEXT-BOOK

ON

ORTHOPEDIC SURGERY

By

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PREFACE

THE purpose of this book is to present to the student, the general practitioner, and the surgeon the subject of orthopedic surgery in a simple and comprehensive manner. The scope of the specialty has been broadened to include many conditions, as fractures, dislocations, and other surgical affections of the extremities, not usually considered in text-books on orthopedic surgery, but which are routinely treated by the orthopedic surgeons in daily practice, and taught by them in many of our leading medical colleges. The preliminary chapters are devoted to the method of routine examination of the extremities and spine, and to the construction and application of apparatus, so that the student may differentiate the normal from the pathologic conditions described in the subsequent chapters, and employ intelligently the principles of mechanical treatment. The author well realizes that any classification of orthopedic affections is largely a matter of opinion and is obviously subject to criticism. Our knowledge at the present time is far from complete, and as additional information is acquired our opinion on many subjects will probably be altered. However, an attempt has been made to give a sufficiently comprehensive classification, especially of affections of joints, bones, and tumors, to afford a clearer exposition of the more complex subjects. The etiology, the various etiologic theories, and the pathology are discussed in as practical and simple a manner as possible, but in the commoner affections a more detailed description is given. Emphasis is placed upon the differential diagnosis, even to the point of repetition, for the especial benefit of the student. No attempt has been made to describe all known methods of treatment, but only those which, in the judgment and experience of the author, are considered to be of practical value. The essentials of modern operative methods are defined, and in many instances the technic described for a better understanding of these principles.

An effort has been made to make a bibliography which is selective and usable rather than complete, and credit has been given, according to the knowledge of the author, to the ideas and methods of others.

If any omissions or errors have occurred, they will be gladly corrected. In conclusion, deep gratitude is expressed to my colleague, Dr. Joseph I. Mitchell, and to Mrs. M. R. Laurents, for their efficient services in the preparation and compilation of the text, and also to my colleague, Dr. J. S. Speed, for his aid in the preparation of the sections on Bursitis and Spastic Cerebral Paralysis. Appreciation is also acknowledged for the excellent illustrations by Mr. Chas. F. Ingram.

WILLIS C. CAMPBELL.

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ORTHOPEDIC SURGERY

CHAPTER I

CLASSIFICATION OF ORTHOPEDIC AFFECTIONS

Orthopedic surgery is that branch of general surgery which deals with diseases and injuries of the bones, joints, muscles, fascias, and nervous system which may impair function or cause deformity at any age. The term "orthopedics" was originally applied by Nicholas Andry, being derived from the two Greek words ὀρθός straighten and παῖς child. The subject has long since outgrown the original definition "to straighten the child," but the term will continue to be employed until one more descriptive of the specialty of today has been advanced. A complete classification of all conditions requiring orthopedic treatment can not be made on a purely scientific basis. There are, however, many affections which bear a more or less close relationship etiologically, clinically, or pathologically, and they will be grouped together in order to present them in a more concise and comprehensive manner. The extremities of bones form an integral part of the articulations and a fine distinction must occasionally be made to determine whether the bone or the joint is involved in the pathologic process. When either is invaded exclusively, the clinical manifestations are distinctly different. Orthopedic affections may be classified into six main divisions:

I. Affections of Joints.
II. Affections of Bone.
III. Affections of the Soft Tissues.
IV. Affections of the Nervous System.
V. Static Deformities.
VI. Congenital Anomalies.

I. **Affections of Joints.**—*Acute infections* result from direct infection of a joint by pyogenic organisms, and are characterized by all the constitutional symptoms of acute inflammation. Joint infections induced by different pyogenic bacteria are often described as separate

clinical entities, but the symptoms, physical signs, and pathology are so closely related that the inclusion of all types as acute infectious arthritis in one description is warranted.

Low-grade affections of joints comprise a large group in which the onset is gradual and often insidious, and the clinical course slow and indefinite. The etiology is well known in some, but in others not yet proved. The pathology and treatment differ to some extent depending upon the etiology.

Traumatic affections include those injuries resulting from repeated mild trauma, which undoubtedly has an important selective action in many joint affections in determining the site of the pathologic process, and from direct or indirect violence to joints, such as sprains, fractures into the joints, mechanical derangements of joints, and dislocations.

II. **Affections of Bone.**—*Traumatic Affections.*—Fractures are caused by a break in continuity of the bone and result from direct or indirect violence.

Acute infections of bone by direct or indirect invasion by pyogenic organisms produce periostitis, osteitis or osteomyelitis. Involvement of the central canal and the osseous structure coincidently is the most usual and is known as acute infectious osteomyelitis.

Low-grade Affections.—Certain abnormal low-grade processes occur in bones as the result of infection, injury, nutritional disturbances, endocrine imbalance, and congenital deficiencies, which are similar in some respects to low-grade affections occurring in joints. The symptoms, clinical course, and prognosis, however, are quite different.

Bone Tumors.—Tumors occurring in bone may be benign, malignant or metastatic, and may be derived from osteogenic cells or from non-osteogenic cells residing in or about bone. Benign tumors always remain localized; malignant tumors invariably metastasize if growth is not arrested, and metastatic tumors, as the name implies, are secondary to malignant processes originating elsewhere in the body.

III. **Affections of the Soft Tissues.**—Certain affections of the skin, muscles, tendons, fascias, bursae, and vascular system may impair function or induce deformity. The etiology, symptoms, and treatment vary in affections of the different structures.

IV. **Affections of the Nervous System.**—Certain clinical entities having a special orthopedic significance result from affections of the central nervous system and peripheral nerves. Those of most common occurrence are anterior poliomyelitis and spastic cerebral paralysis.

V. **Static Deformities.**—Static or postural conditions are mechanical affections resulting from faulty posture which produce definite symptoms from improper distribution of the body weight.

VI. **Congenital anomalies** include all deformities due to embryologic deficiencies or to mechanical or other prenatal influences in utero, such as the well-known abnormalities of clubfoot, congenital dislocation of hip, and wryneck.

CHAPTER II

ORTHOPEDIC EXAMINATION

The prevention and correction of deformities require a comprehensive knowledge of the affections which produce them, and in order to acquire such knowledge a systematic method of examination must be developed. A scientific investigation is as essential in orthopedic conditions as in any obscure internal disorder, and the examination of each patient must proceed in a logical and consistent manner. At the time the patient is first observed by the surgeon, a complete and accurate history is obtained with detailed inquiry as to the chief complaint, the manner of onset, the order in which the symptoms were observed, and other evidence significant from an orthopedic standpoint. The chief complaint, or that which causes the patient to seek aid, is often of value in suggesting the nature of the affection and differentiating it from other conditions. The manner of onset is most important: if sudden, with high fever, an acute pyogenic infection is probably the etiologic factor; if gradual or insidious, without pronounced elevation of temperature, a low-grade inflammation or degenerative process is suggested. The type, character, and distribution of pain are also important clues which may aid in making the diagnosis. If trauma is reported, every detail of the injury must be ascertained, including the time and place of occurrence. The exact relation of trauma to the suspected lesion must be ascertained, as the tendency exists generally to ascribe any disability of the organs of locomotion to remote injuries. The actual connection may often be proved by determining whether the symptoms were coincident with the injury, existed previously, or if not, the period of time that elapsed before the symptoms became apparent. It is often of practical value in eliciting these details to ascertain whether the patient was able to depart from the scene of the accident of his own volition or whether he required immediate aid. These facts must be secured and carefully recorded, not only from the standpoint of scientific interest, but on account of the possibility of a subsequent legal or compensation problem.

The symptoms and signs are objective and subjective: objective signs are those which are obvious, as deformity, attitude, gait, and restriction of motion; the subjective symptoms are those described by

the patient and are not apparent to the examining surgeon. Much tact and judgment are often required in determining the existence and degree of subjective symptoms and in differentiating them from similar complaints by patients who are neurotic, hysterical or malingering. If there is a deformity, it must be determined whether the anomalous condition is congenital or acquired, and when acquired after birth, every means of investigation must be employed to determine the cause.

A careful physical examination of the patient is next made, including all routine, clinical, and laboratory tests, and such special examinations as are indicated by the symptoms and physical findings. The patient is prepared for the examination by the removal of all clothing, unless the affection is obviously confined to a particular part, as a minor injury to an extremity. Valuable information which may have been forgotten is often acquired by observing the body in the nude. Such information may have been purposely omitted or considered of no special importance by the patient. Adult females should be prepared for examination by placing T-straps over the genitals and bibs over the mammary glands, which will permit inspection of the entire body. A thorough knowledge of the normal is required and will be emphasized in the description, so that the abnormal may be recognized. The orthopedic examination may be divided, for the purpose of description, into two parts: (*a*) the body as a whole from the standpoint of posture, and (*b*) the mechanism and characteristics of each member or part.

(*a*) **The Body as a Whole from the Standpoint of Posture.**—Posture may be defined as the attitude of the body with regard to the relation of the several principal members. The position of the body while standing and walking is demonstrated by inspection. Beginning below, the distribution of the weight on the soles of the feet and the relation of the feet to the legs are noted; next, the contour of the legs and their relation to the knees. The relation of the hips to the pelvis, the shoulders to the chest, and the contour of the spine, chest, and abdomen must also be observed. As the patient stands with the feet parallel and the weight evenly distributed, the line of weight-bearing should correspond to a perpendicular passing through the second toe on each foot. Prolonged upward, the lines pass through the center of the patellae and then converge to unite at the lumbosacral joint. The line of weight-bearing in the frontal plane should correspond to the midline of the trunk, neck, and head. Viewed from the side, the line of weight-bearing, if projected upward from the mediotarsal joint, should cross the center of the hip joint and ear. Posteriorly, the tips

of the spinous processes should form a straight line, continuous with the gluteal cleft. The gluteal folds should be at the same level. Normally, a plumbline just clearing the sacrum barely touches the dorsal kyphos.

Normal posture is evolved by growth of the child. At birth and during the first year the vertebral column is straight in the recumbent position, except for a slight backward curvature in the dorsal and sacral

Fig. 1.—Normal posture, anterior view.

Fig. 2.—Normal posture, posterior view.

regions. The physiologic curves in the cervical and lumbar regions are developed in response to functional adaptation and are convex anteriorly. The physiologic curves may be considered compensatory, the cervical being associated with the extension and elevation of the head, and the lumbar with the use of the lower extremities in the hyperextended position, which is correlated with the assumption of the erect posture. The position of the pelvis when the body is erect also

presents important sexual variations. The female pelvis is lighter in construction, the height is less and the flare of its walls is not so pronounced as in the male. According to Cunningham, the position of the pelvis depends upon the length of the iliofemoral ligaments of the hip joint, being more oblique when these are short, as usually occurs in women in whom the anterior superior iliac spines tend to lie in a plane slightly in advance of that occupied by the symphysis pubis. When the iliofemoral ligaments are long, a greater amount of extension of the hip joint is permitted and this leads to a lessening of the obliquity of the pelvis. This condition, which is more typical of men, results in the anterior superior iliac spines lying in a plane slightly posterior to that of the symphysis pubis, while the angle formed by the plane of the pelvic inlet and the horizontal is correspondingly reduced. The lumbar lordosis is likewise usually greater in women than in men.

(*b*) **The Mechanism and Characteristics of Each Member or Part.**—A detailed description of the method of examination of the individual joints will be given separately. A comprehensive knowledge of the anatomy of joints is essential to a full understanding of the subject, as their anatomical construction and functions vary. However, as there are characteristics common to all joints and also to the bones and soft structures between the joints, certain methods of examination are more or less applicable to all, and a general description will be, therefore, more appropriate and will avoid repetition. A definite system should be followed in making the examination, the details of which may be enumerated as follows: (1) Inspection; (2) palpation; (3) passive motion; (4) active motion; (5) mensuration; (6) auscultation; (7) neurological examination; (8) aspiration; (9) roentgenoscopy; (10) biopsy.

1. *Inspection.*—By inspection not only is the posture of the entire body noted, but the appearance, contour, color, attitude, position, and deformity of the individual parts are demonstrated. Inspection also reveals abnormalities in function with active use.

2. *Palpation* is the examination of the body by the sense of touch and elicits such objective symptoms as (*a*) tenderness, (*b*) fluctuation, (*c*) elevation of local temperature, (*d*) the texture and induration of the tissues, and (*e*) changes in contour as may be manifested by inflammatory products or tumors. A finer degree of comparison of the local temperature can be made by employing the same hand successively on corresponding parts of the body, than by using both hands simultaneously. Palpation by both hands is necessary to demonstrate fluctuation, and deep palpation by one or both hands may often detect deep-seated tumors or other abnormalities. Friction fremitus is detected by

a combination of palpation and passive motion and denotes intra-articular friction or vibration.

3. *Passive motion* of a joint is accomplished by carrying the part through the movement of which it is capable. This examination determines the quality of motion and the arc of motion in each direction. The movements should be performed without the assistance of the patient who should be as nearly as possible in a state of complete relaxation. Much tact is often required to elicit passive motion successfully, especially in children when the symptoms are acute. Motion in a joint should be without restriction or inhibition throughout the normal range, but passive motion may be restricted by mechanical obstruction, adhesion of the articular surfaces, or reflex spasm of the muscles about the joint. The quality of motion is thus altered when the joint is diseased, causing limitation of motion, friction fremitus, and crepitation. Friction fremitus is a thrill caused by the contact of two dry surfaces, such as are present in pleurisy, and the same vibration may be perceptible in a joint. Crepitation in a joint is a grating or crackling sensation similar to that produced by the rubbing together of the ends of a fractured bone.

Movement may be free and normal in some directions and limited in others, depending upon the location and extent of the pathologic process, or, motion may be present in a direction in which normally no motion is permitted. Abnormal movement in a joint may be defined as excess motion or false motion. Excess motion is movement in an abnormal direction or an increase in the normal range of movement in one or more directions. Lateral instability of a joint, as the knee joint, may be present in certain individuals in whom joint resistance is less than normal. When thus present it may be a congenital abnormality and will be equally present in both extremities. False motion is also an increase of motion in a direction in which normal movement is not possible, resembling excess motion, but is confined to one joint, being due to impairment of the ligamentous structure of the joint.

4. *Active motion* is movement of a joint by voluntary muscular action and is demonstrated by the patient at the request of the physician. The joint is moved through all possible ranges, and the nature and restrictions of motion are noted. Limitation of active motion may be caused by muscular weakness, reflex muscular spasm, mechanical obstruction, or adhesions of joint surfaces. The elicitation of muscular power is most important and may be determined by having the patient perform voluntary movements against resistance. Active motion and

muscle power are not synonymous, but each is dependent upon the other. The range of motion may be recorded in terms of the plus sign, as will be described under mensuration. Instruments of precision may be employed also to record power, but routinely these are not of great practical value.

5. *Mensuration* is the comparison of a part with the normal by measurement and will demonstrate atrophy, hypertrophy, and loss of continuity. A tapeline is usually sufficient for all practical purposes, and the degrees of passive and active motion can be conveniently recorded in terms of the plus sign, indicating normal range in any given direction by ++++, 75 per cent by +++, 50 per cent by ++, and 25 per cent by +. Less than 25 per cent can be estimated approximately in degrees. Degrees of motion in a joint may be measured

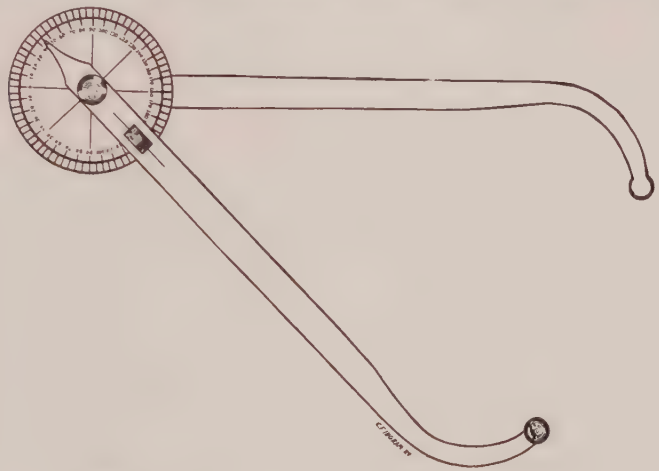


Fig. 3.—Protractor used in measuring joint motion.

by special instruments if extreme accuracy is required. The recent developments in industrial surgery and the enaction of compensation laws demand the adoption of a standard by which joint movement and deformity may be recorded in such a manner as to be readily understood. The instrument by which the range of motion or the angle of deformity is determined is called a joint protractor or goniometer. The protractor consists of two strips of wood or metal connected at one end by a hinge joint. There should be a scale graduated in degrees, reading 0° to 180°, about which one limb of the protractor moves, and by which the angle of deformity may be read. The margin of error is reduced by having the limbs long and of equal length; 16 inches is the usual length. A thumbscrew may be placed at the center so

that the limbs of the protractor may be fixed in position when the instrument is applied at the proper angle on the joint.

The limbs of the protractor are applied so that they are in line with the bony axes of the parts of either side of the joint which is being measured. Deviation from this technic causes the common source of error, particularly in fleshy persons in whom some difficulty is experienced in applying the protractor in the proper line and centering it accurately over the joint. For measuring rotation a protractor with a graduated scale, but without limbs or connecting thumbscrew, is placed over the limb like an arch.

The system which seems most rational, as suggested by Clark, is that in which the arc of the angle included between the bones of either side of the joint is used to express limits of motion or angle of deformity. In this system the stated number of degrees does not represent the number of degrees of an arc through which the part is moved, but the angle of the half circle scale from 0° to 180°, at which it stops. The degrees express the limit of motion and not the amount of motion.

According to this system, complete extension of any joint is 180°, or a straight line. Flexion is defined as the movement of a joint in an anteroposterior plane in the direction of its greatest range. For all joints, except the spine, this movement is cephalic in direction, and for all except the knee and toes it starts in an anterior direction. Flexion of any joint begins at 180° and approaches 0°, the reading of the protractor being in inverse proportion to the angle. The same is true of hyperextension. Abduction starts at the same straight line of 180° and implies a movement away from this line and away from the median line of the body in an arc approaching 0°, just as in flexion, but in a plane at right angles to flexion. Adduction is a movement from the straight line toward the median body line in the same lateral plane as abduction. Rotation is measured at the distal end of the bone rotated. Outward rotation is recorded as being toward 180°, but inward rotation as being toward 0°.

In recording information obtained by measuring the range of a joint, motion may be expressed in the angles read on the protractor and may be facilitated by a simple diagram of the part, as suggested by Nutter. Also calipers, as employed in obstetrics, may be used for securing accurate measurements, and a malleable lead tape may be used to record the contour of the part.

6. *Auscultation* is of value in locating crepitation, snaps, clicks, and friction fremitus in some of the larger joints, and also for the purpose of determining the source of transmitted sounds. The use of the

stethoscope is at times necessary, but this instrument is rarely used, as it is seldom of practical value.

7. *Neurological Examination.*—A complete neurological examination is not required routinely, but a careful testing of the pupillary and knee reflexes and cutaneous sensation is essential in the examination of every adult patient and when lesions of the nervous system are suspected a systematic neurological examination is indicated. When symptoms suggestive of abnormality within the spinal cord are present, a spinal puncture and examination of the spinal fluid are required.

Electrical stimulation of the muscles is necessary in differentiating some neurological affections. For diagnostic purposes the most important forms of electricity are the faradic, interrupted or induced current, and the galvanic or continuous current. In testing the reaction of muscles one electrode should be placed on the spot which it is desired to stimulate, while the other is placed upon a distant, indifferent spot where any muscular contraction that may occur will not interfere with the part under observation. The indifferent pole is usually placed on the back of the neck, or on the abdomen. The patient must be placed in a good light so that the slightest movement of the muscle will be apparent or when the contraction is too faint to be visible it may sometimes be felt by placing one finger over the tendon of the muscle.

Faradic Reactions.—The faradic current stimulates the muscles through their nerve connections. If the electrode is placed over the spot where the nerve enters the muscle, which is known as the motor point, a maximal contraction in the muscle is produced. If the electrode is placed over a nerve trunk, such as the ulnar, or musculospiral, the entire group of muscles supplied by that nerve trunk is stimulated. In testing faradic reactions a feeble current is first used and gradually increased until a contraction is produced. This contraction is then compared with that produced by the same strength of shock applied to a healthy muscle, preferably the same muscle of the opposite limb.

Galvanic Reactions.—The galvanic current stimulates a motor nerve fiber at the moment of closure, and again at the moment of opening of the current, and also during the whole period of flow, provided the current be strong enough. Even when a nerve is degenerated, directly applied galvanism is able to produce contraction in the muscle fibers. A normal muscle is more excitable at its motor point than at any other part, whereas a degenerated muscle is equally excitable at all points on its surface.

Clinical Interpretation.—The polar reactions of a muscle to the galvanic current are of great clinical importance. Normally, the contraction at closure is greater if the stimulation is produced by the cathode or negative pole than by the anode or positive pole. Secondary to the loss of trophic influence and the ensuing chemical changes in the muscles, there appears what is known as the electrical reaction of degeneration. The muscles become nonresponsive to faradic stimulation and galvanic stimulation shows first; the cathodal closing contraction

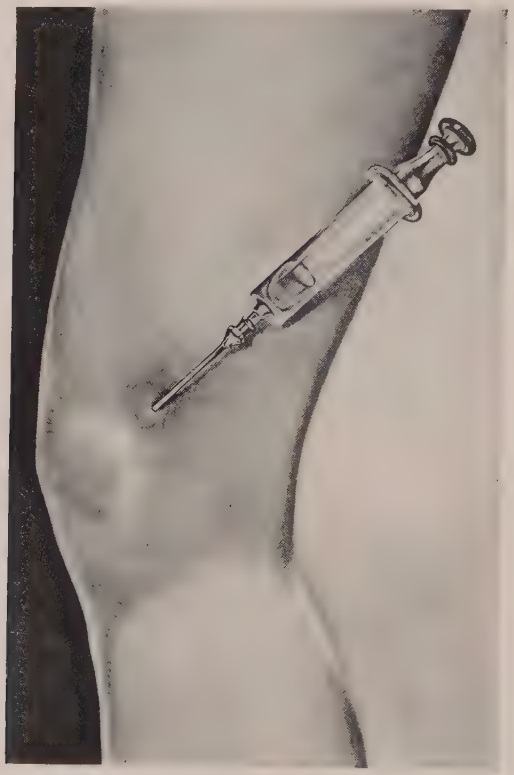


Fig. 4.—Method of aspiration of knee joint.

becomes equal to anodal closing contraction (C. Cl. C. = A. Cl. C.); finally the anodal closing contraction becomes greater than cathodal closing contraction (A. Cl. C. > C. Cl. C.). The first of these changes is spoken of as the *partial reaction of degeneration;* the second, as the *complete reaction of degeneration.* In literature this is abbreviated to R. D. Although trophic change seems to be dependent on both the afferent and efferent limbs of the arc, the reactions of degeneration usually follow involvement of the anterior cornual cells or their axons

and not of the afferent limb. For further discussion of the electrical changes, the reader is referred to works on the subject.

8. *Aspiration* by a needle and syringe is required when excess fluid is present in a joint as denoted by fluctuation on palpation. The syringe should not be smaller than 10 cc. The needle should be at least 2 inches in length and from 16 to 18 gauge, depending upon the consistency of the fluid. In order to avoid leakage with subsequent infection of the part, the needle is inserted, first, into the skin, traversing the subcutaneous tissues for a short distance, when the needle is thrust directly into the joint. By this technic, the openings in the skin and joint capsule do not coincide. The character of the fluid as to color and consistency is noted, after which the fluid is submitted to the laboratory in a sterile container for complete analysis. Culture, microscopical examination, and the Wassermann test of the fluid should be routinely employed and such other tests, as animal inoculation, as may be suggested by the clinical signs and manifestations.

9. *Roentgenoscopy.*—The relative value of the roentgen ray as a diagnostic agent must be comprehended, otherwise false conceptions of the reliability of this agent will arise. As in the microscopical examination of a pathologic specimen, a diagnosis should not be made without taking into consideration all other methods of investigation and examination. A single negative observation does not exclude pathology in bone, as no alteration is apparent until there has been a change in structure or break in continuity. Weeks, often months, may elapse in the course of bone disease before definite changes can be demonstrated by the roentgenogram. Also a progressive process may exist within a joint for a very long period without manifesting changes in the adjacent bones. Even death may ensue from a disease within a bone without there being any visible manifestations by the roentgenogram. However, a negative roentgenogram is of material value, as by comparison with future roentgenograms slight manifestations may be elicited much sooner. The roentgenogram is also of value in determining the progress toward recovery and the effect of treatment upon the local process. The fluoroscope is of little practical value as a diagnostic agent, but the roentgenogram must be routinely employed. The quality of the roentgenogram must be excellent before manifestations can be accepted as diagnostic evidence; unless a direct view is made in any part of the body there will be a distortion of the shadows upon the film. Erroneous diagnoses are frequently made from poor films. There also seems to be a tendency, or possibly a temptation, by those of little experience to interpret artefacts and

unusual shadows as pathologic processes which, to one of mature judgment and knowledge of the subject, would be of no significance. Familiarity with the appearance of the normal epiphyses is essential, as errors have frequently been made in confusing the epiphysial lines with fractures.

In all routine examinations, roentgenograms of both sides should be made for comparison, and whenever possible, two views made at different angles are absolutely necessary. When the third dimension is not obtainable, as in the regions of the pelvis and shoulder, stereoscopic roentgenograms are essential. Abnormalities of the surrounding soft structures can usually be demonstrated by physical examination long before they become apparent by the roentgenogram. Tumors of the soft parts and inflammatory products may be manifested by an increase in density of the shadows. Abnormalities of the intra-articular structure, as the encrusting cartilage, are usually apparent by a change in relation of the articular surfaces, as demonstrated by increase or decrease of joint space.

Bone is more dense or opaque than any other tissue, and is, therefore, better defined by the roentgenogram, and will show more clearly pathologic changes, when present, than other tissue. The pathologic changes which are apparent in bone are of three types: (*a*) atrophy, (*b*) hypertrophy, and (*c*) destruction, although a combination of any two or the three processes may be present in the characteristic visualization of a pathologic process by the roentgen ray.

(*a*) Atrophy is a dimunition or wasting of osseous structure, denoted by paleness as compared to normal bone. There is first a loss of lime salts, during which period the bone trabeculae become more apparent, standing out in marked contrast to the softer portions. Later there is a characteristic mottling by light and dark areas with obliteration of the trabeculae from loss of lime salts.

(*b*) Hypertrophy is either an increase in size of the affected area in bone or an increase in structural density, and may be regular either by enlargement of the entire bone, or by osseous proliferation about and within a circumscribed portion of the bone.

(*c*) Destruction of the bone may be complete, or there may be superficial or deep areas of erosion on the surface; there may also be areas of destruction within the interior of the bone. Metaplasia is of frequent occurrence and may be considered as a type of destruction. It is the substitution of bone by a different type of tissue from the same embryological type. The most frequent substitution is by osteoid tissue.

10. *Biopsy.*—As in other diseased organs, an excision and examination of tissue from a bone or joint is often required before an accurate diagnosis can be made. However, biopsy can not be employed as a routine measure, but is only used where other means are not conclusive.

THE FOOT AND ANKLE

The order of description of the routine examination as applied to each special joint will be from below up, beginning with the foot. The examination of each joint must be strictly carried out; however, some of the procedures are not of sufficient value to be routinely employed, and in certain joints, therefore, will be omitted. The functions of the foot and ankle are so closely related as to warrant the inclusion of both in one description.

Inspection.—The patient is requested to stand, if possible, with the feet parallel, when the distribution of the body weight upon the bearing surfaces of the feet is noted. Posteriorly, the position of the tendo achillis and its relation to the os calcis are observed. Abnormality in contour, size, or color may be readily seen. Walking is requested to demonstrate abnormality in gait.

Fig. 5.—Normal distribution of weight on feet and ankles.

Palpation.—The soles and dorsal surfaces of the feet are palpated for abnormality in contour, swelling, and tender points. The ankle joint and lower third of the leg are examined in the same manner. The anterior tibial artery is palpable on the dorsum of the foot and the posterior tibial artery behind the internal malleolus. Pulsation in these arteries should always be determined, as arterial changes may be a primary or contributing factor in many foot affections.

Passive motion of each toe may be elicited, if indicated by local symptoms. Motion in the midtarsal and tarsometatarsal joints is determined by grasping the forefoot with one hand and the heel with the other, and moving the forefoot from side to side on the posterior portion of the foot. Normally, there should be about 10 degrees of motion. Motion in the subastragalar joint is difficult to elicit, as it is

usually associated with ankle motion. Passive motion in the ankle joint can be detected by grasping the foot and passing it through the normal arcs of motion. Flexion (dorsiflexion), extension (plantar flexion), eversion, inversion, and restriction or abnormality in quality of motion, may be apparent and can be recorded. Normal dorsiflexion is possible until the dorsum of the foot makes an angle of about 75 degrees with the anterior surface of the leg; in plantar flexion the angle is 140 degrees.

Active Motion.—The foot and ankle are next tested for active motion and muscle power. The patient is requested to dorsiflex the

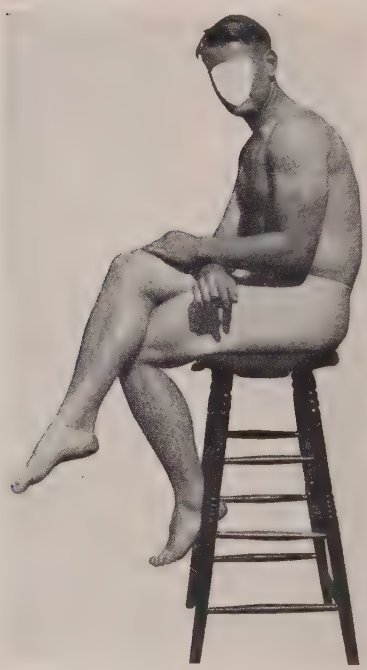


Fig. 6.—Normal range of plantar flexion of foot.

Fig. 7.—Normal range of dorsiflexion of foot.

foot and toes. The range of motion is apparent, and if the foot is grasped by the hand, resistance or power of the extensor muscle can be determined. Plantar flexion of the foot by the gastrocnemius and soleus muscles is elicited in the same manner and also plantar flexion of the toes. Abduction by the peroneal muscles is next elicited, and lastly, adduction by the anterior and posterior tibial muscles which is of the greatest importance, as the integrity of the tibial muscles is essential to normal weight-bearing. By comparison with normal

joints, abnormalities in muscular strength and range of motion are readily apparent. Muscle power is tested also by such exercises as rising on the toes.

Mensuration.—Measurements of the foot may be employed as from the malleoli to some bony prominence of the tarsal or metatarsal bones, but are rarely necessary, differences in width and length being easily determined by comparison on inspection. Measurement of the circumference of the ankle joint and foot at successive intervals may be employed as a prognostic method to determine increase or diminution of swelling. As the length of the limb is rarely altered materially in affections of the foot and ankle, longitudinal measurements are seldom of value, but may be obtained by measurements from the anterior superior spine to the center of the sole of the heel with the foot at a right angle to the leg.

Fig. 8.—Normal range of abduction of right foot and adduction of left foot.

Auscultation is of slight, if any, value in the ankle joint.

Neurological Examination.—The Achilles reflex is tested by striking the tendo achillis while the foot is supported at a right angle. The reflex action may be increased or diminished and may be of different intensity on the two sides. The plantar reflex or Babinski's sign should also be tested, as well as other associated phenomena, as the Gordon, Oppenheim, and Chaddock reflexes, and, if abnormalities are apparent, a meticulous and complete neurological examination is required.

Aspiration of the ankle is indicated when fluid is present and the diagnosis, after the other routine methods have been employed, remains in doubt. Aspiration is best accomplished on the anterolateral aspect of the ankle joint about $\frac{1}{2}$ inch above and external to the external malleolus. At this point there is no danger of injuring any important structures as nerves, vessels, and tendon sheaths. Rarely can more than 1 or 2 drachms of fluid be removed.

Roentgenoscopy.—The roentgen examination of the foot requires the exposure of two films, one in the anteroposterior view and one in the lateral view. Two views are also required of the ankle. One lateral view of the foot and ankle can be made on the same film and is sufficient for both the foot and ankle, but a separate supero-inferior view is

essential for the foot and an anteroposterior view for the ankle. If a careful examination of the os calcis is required, a supero-inferior view is necessary and can be obtained by dorsiflexing the ankle to the maximum degree and focusing the rays through the plantar surface of the heel. Both sides should usually be exposed for comparison.

Biopsy should be frequently employed in the ankle, as the joint is quite accessible through an anterolateral incision beginning about 1 to $1\frac{1}{2}$ inches above the external malleolus and passing down to the mid-tarsal joint. Inspection of only a small portion of the anterolateral aspect of the joint can be made, but a section of the capsule, or of the granulation tissue, or any other abnormal growths within the joint can be secured for microscopical examination and bacteriological culture.

THE KNEE

The knee is the largest, most complex joint, and is more frequently injured and involved in pathologic processes than any other joint in the body. The stability and integrity depend entirely upon ligamentous support on all four sides and within the joint.

Inspection.—The bony landmarks and other structures about the knee joint, as tendons, are apparent on inspection of the normal knee, therefore, any swelling or abnormality within or surrounding the joint is easily detected by observation. The contour of the joint is observed on all four sides with the patient standing in the normal attitude. The relation of the leg to the thigh and the knee to the hip is noted. Abnormal contour, color, and deformity are apparent and abnormality in function, as limp, is observed in walking.

Palpation.—The joint is palpated on all sides and any irregularities, points of tenderness, or other abnormalities detected. As a finer comparison in local temperature can be made when one hand is employed than when both hands are used, surface heat is determined by placing the same hand upon each knee successively. Fluctuation of fluid within the joint or in the bursae about the joint can be elicited by palpation with both hands. When the joint is distended, the patella can be felt anterior to and floating on the surface of the fluid. On compression, the patella strikes the condylar surface of the femur and rebounds, this sign being known as ballottement. Loose and pedunculated bodies may rarely be palpated within the knee joint, but, as a rule, are inaccessible in the recesses of the joint cavity. The popliteal artery is palpable on the posterior surface of the joint, deep between the tendons of the hamstring muscles.

Passive Motion.—There are, practically speaking, only two movements of the knee joint, flexion and extension, which are accompanied, however, by rotation of the condyles of the femur on the tibia. The

Fig. 9.—Normal range of flexion of knee.

external condyle acts as a pivot about which the internal condyle rotates. Passive motion in flexion is possible until the calf of the leg approximates the posterior aspect of the thigh, making an angle of

Fig. 10.—Normal range of extension of knee.

35 degrees. Extension begins when the leg is fully flexed and is completed when the leg forms a straight line with the thigh or 180 degrees. In some individuals normal extension may be increased, allowing slight hyperextension, the angle between the anterior surfaces of the thigh

and leg becoming 170 degrees. Rotation of the tibia on the femur is chiefly passive and is checked by the crucial ligaments.

Lateral motion is elicited when present by grasping the ankle and fully extending the knee, when a rocking movement of the leg from side to side is attempted. In a normal knee there should be no lateral motion possible, though in some loose-jointed individuals that are considered normal, definite lateral movement may be present, but always in both knees, so a comparison must always be made. The laxity in such cases is probably congenital. Lateral motion in one knee only indicates ligamentous impairment. If the internal lateral ligament is defective, there will be increased motion to the lateral aspect and if the external lateral ligament is defective there will be increased motion to the inner aspect. The crucial ligaments can also be tested by movements of the joint. The integrity of the posterior crucial ligament is determined by flexing the knee at a right angle and attempting to glide the tibia backward upon the femoral condyles by grasping the upper extremity of the tibia with both hands and forcing it backward. If the ligament is intact, no motion is possible, otherwise, the tibia will glide backward and become subluxated upon the femur. The integrity of the anterior crucial ligament is tested with the knee in full extension. If the ligament is ruptured the tibia can be made to glide forward upon the femur; this is not an exaggeration of hyperextension, but an anterior displacement. Friction, crepitation, roughness or restrictions will be apparent when the knee is moved passively and actively.

Active Motion.—Active flexion and extension are elicited by having the patient alternately flex and extend the knee of his own volition. Muscle power is determined in the same manner by resisting the effort of the patient. The integrity of certain muscles can be determined by electrical stimulation, but for all practical purposes palpation of muscles, when in action, is sufficient. Efficiency of the knee depends largely on activity of the quadriceps muscle, the power of which should be carefully tested.

Mensuration is not so important in determining affections of the knee as of the hip joint. The length of the femur may be determined by measurement from tips of the greater trochanter to the joint line on the lateral aspect. The length of the leg may be determined by measurement from tip of the upper extremity of the fibula to the external malleolus, or from the joint line on the inner aspect to the tip of the internal malleolus. Circumference of the knee can be ascertained by a tapeline and is often of value in determining the extent of swelling from time to time which is often an indication as to the progress of

the affection within the joint. Measurements from the anterior superior spines of the ilia to the tips of the internal malleoli of both limbs will give the comparative lengths.

Auscultation is employed to locate certain obscure snaps or clicks, crepitation, and friction fremitus. The latter is identical with that heard in the early stages of pleurisy. Auscultation is employed in the knee more often than in other joints, but is rarely of practical value, as most signs so elicited can be determined by palpation and passive motion.

Neurological examination is of special importance in the knee, as diseases of the spinal cord are more frequently manifested by trophic disturbances in the knee than in any other joint. The patellar reflex is demonstrated by tapping the patellar tendon lightly with the hand or percussion hammer. Reinforcement of the action may be secured when the reflex is difficult to elicit by detracting the patient's attention, having him close his eyes, clasp his hands or count. As, with the Achilles reflex, the action may be either increased or diminished, and may or may not be equal on the two sides.

Aspiration may be routinely employed when fluid is present, as the knee is a superficial joint. The technic of aspiration has been previously discussed. The needle is inserted on the level with the upper extremity of the patella on the outer side of the joint.

Roentgenoscopy.—In the roentgenologic examination two exposures of the knee should always be made, an anteroposterior and a lateral. For the anteroposterior, the knee is extended, with the posterior aspect upon the table. For the lateral view the patient rests upon the affected side with the knee in about 150 degrees flexion and with the external aspect of the knee on the table approximating the film. The opposite knee is extended so as not to obstruct the rays. Roentgenograms of both knees should usually be made. When the knee is fixed in flexion the routine anteroposterior view is impossible, but may be secured frequently with satisfaction by attaching a film to a cylinder which is placed in the popliteal space and the roentgenogram made by focusing through the joint. By such an exposure, it is often surprising how satisfactory a portrayal of the interior of the joint is possible. Rarely a stereoscopic examination may be required.

Biopsy.—An incision into the joint for the purpose of inspecting the interior of the joint and the removal of diseased tissue to be submitted to the laboratory for microscopical examination and diagnosis is more frequently indicated in the knee than in any other joint, as the knee joint is more accessible and also more frequently affected by

disease or trauma. The location of the incision depends upon the symptoms, but usually an internal lateral incision parallel with the patella is sufficient. A specimen from the synovia or any abnormal tissue is taken.

THE HIP

The physical signs of disease in the hip joint are often obscured by the muscles, fat, and fascia, which overlie the joint on all sides. The routine examination is as follows:

Inspection.—The attitude, position, and contour are first observed. The position and relation of the trochanters of the femurs are noted. In a normal hip the gluteal folds should be on the same level, but when

Fig. 11.—Normal range of flexion of hip.

there has been a change in the relation of joint surfaces and destructive changes within the joint, there will be a difference in the position of the fold on the affected side in relation to the normal hip which will become either higher or lower. The stamina of the muscles which pass from the pelvis to the thigh is demonstrated by the Trendelenburg sign. The patient stands on one leg with the opposite knee and hip

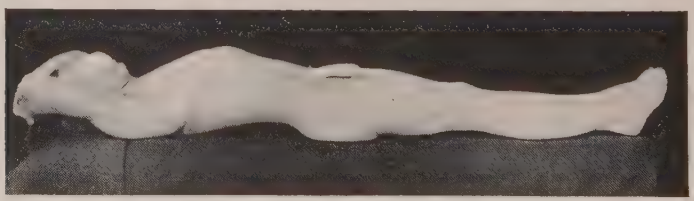


Fig. 12.—Normal range of extension of hip.

flexed to about 90 degrees; each side is tested separately. The buttocks and gluteal folds remain on the same level when the patient stands upon the normal limb. If there is muscular impairment or mechanical instability there will be deflection of the pelvis on the opposite side, the buttocks and gluteal fold assuming a lower level. On walking, any abnormality of gait, as limp, is apparent. There are many definite

gaits which are characteristic and which will be diagnostic of the condition to one trained in observing this detail, though this knowledge is acquired only by long experience. Of such characteristic gaits may be mentioned the short leg limp due to inequality of length of the lower extremities, the stiff hip gait, when the joint is ankylosed; the waddling gait in congenital or acquired dislocations and the swaying gait, associated with a thrust of the body to the opposite side when there is paralysis of the extensor muscles or of the gluteus medius and minimus muscles.

Fig. 13.—Normal range of abduction of hip.

Fig. 14.—Normal range of adduction of hip.

Palpation.—The anterior aspect of the hip is first palpated, as early swelling or induration is first manifested anteriorly. The lymph glands in the inguinal region and saphenous gland can be palpated and enlargement noted. The abdomen above Poupart's ligament is deeply palpated, as inflammatory products or tumors may simulate affections of the hip joint, and in the late stages of hip joint affections a definite mass may be palpated above Poupart's ligament. Deep pressure should also be made to elicit points of tenderness. The exterior and posterior aspect of the hip joint should be palpated in like manner. Deep pressure should be made over the greater trochanter which may induce pain, indicating intra-osseous inflammation under pressure. On account of the location of the hip joint beneath so many muscles

it is more difficult to elicit information by palpation. Local elevation of temperature, induration, and change in contour are often late manifestations after a pathologic process has extended beyond the joint into the surrounding tissues.

The femoral artery may be palpated in the groin just below Poupart's ligament. The location of this artery is often of value in determining the relation of the head of the femur to the acetabulum in cases of suspected dislocation of the hip joint. When the head of the femur lies within the acetabulum, it can be felt on careful palpation, under the point of intersection of a line following the femoral artery with a line crossing the pelvis transversely at the symphysis pubis. Changes in position of the hip joint may also be determined by the relation of the greater trochanter to Nélaton's line. This line extends from the anterior superior spinous process to the most prominent part of the tuberosity of the ischium, and normally should pass just above the tip of the greater trochanter. If the trochanter lies

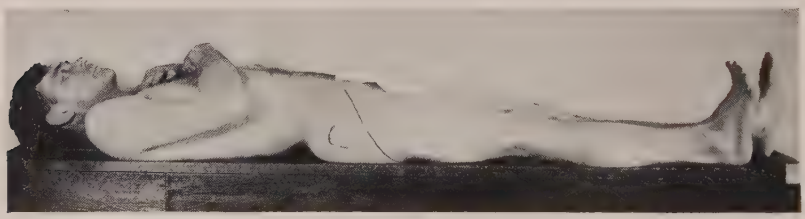


Fig. 15.—Greater trochanter above Nélaton's line.

above the line, structural abnormality, internal to the trochanter, is present in the neck or head of the femur or in the acetabulum.

The triangle described by Bryant may be used in a similar manner to determine displacement of the hip joint. The perpendicular side of this triangle is formed by a line encircling the body on a level with the anterior superior iliac spines. A line is drawn from the anterior superior spine to the summit of the greater trochanter on each side, and the base of the triangle corresponds to a line drawn from the greater trochanter to the perpendicular line, being parallel with the table upon which the patient lies. The measurement of the length of the base of the triangle in comparison with the corresponding line on the opposite side determines the amount of ascent of the greater trochanter and the difference in length of these two lines represents the amount of shortening of the limb.

Passive Motion.—The normal physiologic movements of the hip joint are flexion, extension, abduction, adduction, internal rotation, and

external rotation. In order to demonstrate these movements the patient is placed upon a firm surface, as a narrow examination table. There must be sufficient free space on all sides to permit the normal range of motion in each direction. Flexion is demonstrated by grasping the ankle with one hand, while the other fixes the pelvis by pressure over the anterior superior spine of the ilium. The knee is flexed upon the thigh to relax the hamstring muscles. The hip is then flexed to the extreme limit, which, in children and young adults, is reached when the anterior aspect of the thigh touches the abdomen. In older individuals the thigh may form an angle with the trunk of about 60 degrees, and be within normal variations. Flexion should continue in the same plane; if rotation is associated, there is usually structural anatomical defects. The hip may be extended to 180 degrees or a straight line. Hyperextension is estimated with the patient in the prone position. The ankle is grasped with one hand, while the pelvis is fixed with the other by pressure upon the posterior aspect of the sacrum. The knee is flexed to 90 degrees and the limb lifted from the table. In young children, about 140 degrees without motion of the pelvis is at times possible, while in adults the normal range of hyperextension is from 160 to 170 degrees, the angle being estimated by the distance between the back of the thigh and the lumbar region of the spine.

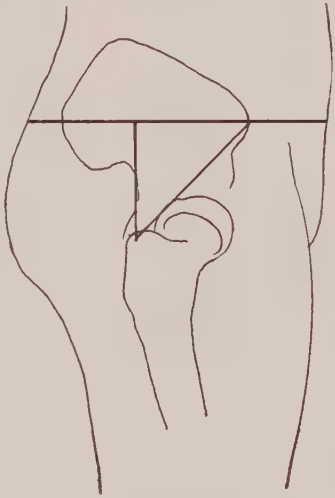


Fig. 16.—Bryant's triangle.

Abduction is performed by moving the limb outward with the hip and knee extended. One hand grasps the ankle, while the other, over the crest of the ilium, fixes the pelvis. Care is taken that the limb remains in the neutral or anatomical position, otherwise external rotation will permit flexion and this complicates or masks the movement. In children, abduction is possible to an angle of 130 or 120 degrees between the lateral aspects of the thigh and trunk; in adults 135 degrees is about the average. The opposite limb must remain passively upon the examining table in the anatomical position, or in unruly and very nervous individuals both limbs may be abducted at the same time. In all cases comparison of both extremities should be made. Adduction is accomplished by grasping the ankle and carrying the limb across the anterior aspect of the opposite thigh. One

hundred and forty degrees is possible in children and about 145 degrees in adults. Internal rotation with the knee extended is estimated by grasping the ankle and twisting or rotating the limb inward. The range is recorded as determined on an arc passing over the foot, 0° being the plane of the table on the inner side of the foot and 180° the plane on the outer side. Normal internal rotation varies from 60 to 70 degrees. External rotation is determined in the same manner and

Fig. 17.

Fig. 18.

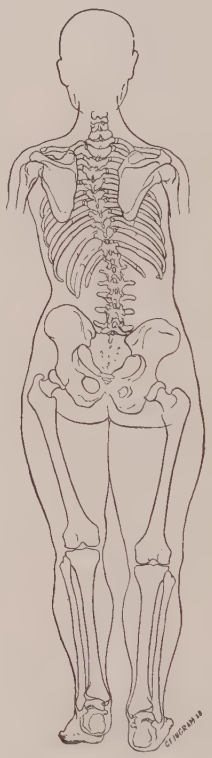


Fig. 19.

Fig. 17.—Hip ankylosed in flexed position, the spine held straight.

Fig. 18.—Hip ankylosed in flexed position. Note compensatory lordosis of spine to place legs parallel.

Fig. 19.—Tilting of pelvis with apparent inequality in length of legs. There is no actual difference.

is possibly slightly in excess of internal rotation, being to 135 degrees. If a normal individual is placed in the reclining position, the forefoot will make about one third of a half circle from extreme external rotation to extreme internal rotation. Rotation can also be estimated by greater leverage when the hip and knee are flexed to about 90 degrees.

In estimating all movements, the pelvis should be fixed to prevent compensatory motion of the spine. When motion of the hip is restricted by muscular spasm, contraction or ankylosis, compensatory movement is secured by motion of the lumbar spine. For example, when the hip is fixed in flexion, there must be motion at some point to enable the sole of the foot to be placed upon the floor in walking; this is obviously possible only by movement of the lumbar spine. A well-known test of hip disease, described in the older text-books on surgery, is based upon fixed flexion of the hip and may be described as follows: the patient is placed in the reclining position on a firm table with the knees parallel. The popliteal space of the affected limb is forced against the table; if the hip is fixed in flexion, lumbar lordosis will be increased so that a space is formed between the spine and the table. The exact angle of flexion deformity can be determined only by flexing the normal hip to the fullest extent. This fixes the pelvis and straightens the lumbar spine; if contracture is present the affected thigh is elevated from the table to a corresponding degree. Contractures of the hip, in other positions besides flexion, are also accompanied by a compensatory range of spinal movement.

Active motion is tested, as in the knee, by having the patient voluntarily move the joint. Flexion, abduction, and adduction may be performed with the patient in the erect or recumbent position; extension and hyperextension is best tested with the patient lying prone on the table. Muscle power of the various groups of muscles about the hip joint should also be determined. Normal power of the flexor muscles can be roughly estimated by having the patient raise the leg from the table while in the recumbent position.

Mensuration.—More valuable information concerning the hip is derived by mensuration than in other joints, as malposition and loss in continuity from destructive pathologic processes are apparent earlier in this region than elsewhere in the skeletal system. The patient should be placed as nearly as possible in the anatomical position in taking the measurements, as one may be deceived by postural deviation of the lumbar spine and pelvis. In fact, any normal individual may apparently lengthen and shorten his limbs at will. The circumference of the midthigh is taken on both sides. A decrease indicates atrophy from lack of use; an increase may be caused by inflammatory swelling of the part. The longitudinal measurements are made to determine (1) the actual or true length and (2) the practical or apparent length of the limb. The true length is determined by measurements from the tip of the anterior superior spinous process to the tip

of the internal malleolus. The apparent length is estimated by measurement from a point above the pelvis, such as the umbilicus or the ensiform cartilage, to the tip of the internal malleolus on each side. Apparent length is affected by the elevation or declination of the pelvis and by compensatory movement of the lumbar spine when motion of the hip is restricted. For example, when the hip is fixed in abduction, in order to approximate the limbs, motion must occur at some other point; this point is the lumbar spine. When there is lateral bending of the lumbar spine with declination of the pelvis on one side, there is an elevation of the pelvis on the opposite side. Thus the abducted limb may appear several inches longer, or the opposite limb, which is adducted, several inches shorter, when, in reality, there is no actual difference. Twists and curvatures of the spine also affect the lateral declination of the pelvis and render the limbs apparently or practically longer or shorter. On account of this compensation of the spine and declination of the pelvis, it is often difficult or impossible to convince the layman that such a condition is apparent and not real. The irregular practitioners and various forms of charlatans, from ignorance or otherwise, often diagnose such apparent changes in length from position, as dislocation, when, in reality, no actual displacement exists.

Auscultation.—As the hip joint is deeply situated, auscultation is of little practical value.

Neurological Examination.—The neurological examination is important and should be employed, especially in all joint affections in persons above thirty years of age.

Aspiration is not so frequently required in the hip as in the more superficial joints, but when indicated can be made from three directions. The needle should be inserted just below and anterior to the greater trochanter close to the bone, after which it is directed upward and inward and slightly backward at an angle of about 45 degrees, in close proximity with the neck of the femur. If fluid is present in the joint, the capsule will be punctured at the outer anterior aspect. The needle must remain parallel with the neck and not deviate anteriorly, as there may be danger of injuring the femoral vessels. However, this danger is very slight, as the capsule will be punctured before the needle comes close to the artery. The anterior route is preferable, but aspiration may also be made from a point just above the greater trochanter or from the posterior aspect, especially in those instances when the capsule is distended in these directions.

Roentgenoscopy.—The roentgenologic examination of both hips

should be routinely made, and if there is any reason to define accurately the location of an affection or anatomical displacement of the joint, stereoscopic roentgenograms should be made. At times the side view of the hip may be of value in demonstrating relations or pathology, but is not required routinely. When making the roentgenogram, care should be taken to place both limbs in the anatomical position, with the feet parallel, as rotation of the femur may materially affect the apparent relation in the joint. This position may be secured by tying the feet together or by using sand bags or wooden blocks.

Biopsy is rarely employed in the hip, as the exposure of the hip joint is a formidable surgical procedure.

THE SACRO-ILIAC JOINT

The differentiation of lesions of the sacro-iliac joint from those of the lower lumbar spine and lumbosacral region is often difficult, and for this reason a very careful examination is required of the sacro-iliac joint. The routine examination is as follows:

Inspection.—The contour of the spine and the relation of the spine to the pelvis are noted, also the relation of the crests of the ilia to one another. Lateral deviation of the lumbosacral region, so-called sciatic scoliosis, is often apparent in affections of the sacro-iliac joint. The characteristic attitude assumed in affections of this region is caused by muscular spasm from joint irritation and is analogous to the attitude assumed from reflex muscular spasm in other joints, as the knee and hip. However, peculiar attitudes from affections of the spine and sacro-iliac joints are often ascribed to dislocations. The elevation of one side of the pelvis from sciatic scoliosis induces a practical or apparent shortening of one limb and lengthening of the other, as explained in the description of examination of the hip. On inspection there may also be observed a change in contour of the region of the sacro-iliac joint caused by inflammatory exudates, abscesses and tumors. The joint is largely obscured by the overhanging crest of the ilium, and changes in external contour are usually a late manifestation of a pathologic process. In walking a definite or persistent limp may be apparent.

Palpation.—The patient is requested to stand with his back to the examiner when deep palpation is made over the sacro-iliac joint, principally to detect tenderness and change in contour from inflammatory processes, abscesses, or tumors. A rectal examination should be made for palpation of the anterior aspect of the joint. Valuable information concerning the joint is rarely secured by this examination, but the

examination does enable the physician to exclude lesions of the rectum and lower bowel, such as carcinoma or other growths in the pelvic organs which frequently cause low-back pain. Tenderness may be elicited at the point of exit of the sciatic nerve from the sacro-sciatic notch, and also along the course of sciatic nerve in the thigh because this nerve is formed over the anterior aspect of the sacro-iliac joint, and any abnormality of that joint may cause irritation of the nerve trunks at their points of exit from the spine.

Passive Motion.—Appreciable motion can so rarely be demonstrated in the sacro-iliac joint that for all practical purposes it may be considered absent. Motion does occur between the sacro-iliac joints and the symphysis pubis simultaneously and consists of a forward and backward or tilting movement of the sacrum on the ilia, or ilia upon sacrum, about a transverse axis situated near the middle of the sacrum. Motion is always greater in women than in men, and is increased during pregnancy. In certain rare instances motion is said to be demonstrable in the sacro-iliac joint by grasping the ilia. Certain forces induce movement in these joints, and when pain is elicited by the manipulation, it is a valuable diagnostic symptom.

Kernig's Sign.—The Kernig sign, as employed by Goldthwait to determine affections of this region, is elicited by placing the patient in the reclining position and flexing the hips with the knee flexed when no symptoms are apparent. Each hip is then alternately flexed with the knee extended, when pain will be experienced in the sacro-iliac joint of the affected side. This is probably caused by slight motion in this joint which is produced by the pull of the tense hamstring muscles through their attachments to the tuberosity of the ischium. The exact time of the occurrence of pain is a valuable point in the differentiation of lumbosacral and sacro-iliac involvement. One hand is placed under the lumbar spine, the other flexes the hip; if pain is experienced before motion is detected in the lumbar spine, sacro-iliac involvement is indicated. If the patient does not complain of pain until there is movement in the lumbar spine, the affection is in all probability in the lumbosacral joint.

Compression of Iliac Crests.—Pain may also be produced in lesions of this joint by firm pressure over the iliac crests. The patient is requested to lie on his side upon a firm surface, as the examination table. Strong pressure is made upon the crest of the ilium, which may elicit pain in the affected joint. Both sides should be tested. Variations of this test are backward pressure over the symphysis pubis with the patient lying on his back which may cause slight motion in

the joint, and also extreme abduction of the hip joint associated with flexion and outward rotation.

Gaenslen's Sign.—Gaenslen has described a diagnostic maneuver which is useful, not only on differentiating the side on which the lesion exists, but also on differentiating sacro-iliac affections from those of the lumbosacral articulation. The patient is brought well to the side of the table with one limb hanging free; the opposite knee and hip are flexed acutely to fix the pelvis. The free thigh is slowly hyperextended by the examiner with gradually increased force. The hyperextension of the hip exerts a rotating force on the corresponding half of the pelvis in the sagittal plane, through the transverse axis of the sacro-iliac joint. The pull is made through the Y-ligament and the muscles attached to the anterior superior and anterior inferior spines of the ilium. As a result of impaired ligamentous support on the affected side, this rotating force causes abnormal mobility accompanied by pain, either local or referred, on the side of the lesion.

Active Motion.—There is no active motion demonstrable in the sacro-iliac joint, but in lesions of the joint there is reflex spasm of the spinal muscles with definite limitation of motion in the lumbar spine. Motion is restricted in flexion and side-bending. When the spine is flexed, normal motion is possible for a considerable degree, but when forced the spine twists toward the affected side, combining side-bending or lateral motion with flexion. This irregularity is obviously due to nature's effort to prevent traction upon a diseased or irritated joint. Side-bending is usually more restricted toward the normal side and less restricted, or at times normal, toward the affected side. This is due to the fact that side-bending away from the affected joint causes increased tension on the muscles inserted upon the crest of the ilium on the affected side; and flexion toward the affected side relaxes the muscles and relieves pressure.

Mensuration.—The limb on the affected side is often apparently longer than the opposite limb, but this difference is only apparent and not real, as all measurements will demonstrate the limbs to be of the same length. The apparent difference is due to the tilt of the pelvis and lumbar spine from muscle spasm, and may be demonstrated by measurements from the umbilicus or any point above the pelvis to the tip of each internal malleolus. This phenomenon has been described previously in the examination of the hip joint.

Auscultation.—A definite click or snap at times may be elicited over the sacro-iliac joint when the hip of the same side is suddenly flexed with the knee extended. The exact cause of such a sound has

not yet been satisfactorily explained, but is probably due to movement in the sacro-iliac joint. The sound is usually audible without the use of a stethoscope, and may be associated with a palpable vibratory sensation.

Neurological examination is especially indicated in all lesions of the sacro-iliac joint to differentiate them from lesions of the spinal cord, which may closely resemble affections of this region. In addition to testing the patellar and Achilles reflexes, the plantar reflex should also be determined, as extension of the big toe or Babinski's sign is often present in affections of the nervous system. The cremasteric and anal reflexes should also be tested and the cutaneous sensation of the perianal region should also be determined, as tumors or other lesions of the lower segments of the spinal cord and the cauda equina will frequently produce anesthesia in this area.

Aspiration.—This joint can not be reached by an aspirating needle, but whenever an external mass is apparent, aspiration is indicated, and is often of material value.

Roentgenoscopy.—Roentgenograms of the entire pelvis should be made, including both sacro-iliac joints. As the lateral view of the joint is not practical, a stereoscopic series in the anteroposterior plane is often required. The roentgenogram will demonstrate the pathology in affections of this joint in only a small proportion of cases; when present, the pathologic changes may be of three types: (*a*) irregularity or displacement as indicated by a change in relation of the sacrum to the rest of the pelvis; (*b*) proliferation as denoted by lipping at the lower extremity of the joint, and at times throughout the joint; (*c*) erosive and destructive changes in the joint. Differential diagnosis of the nature of the process when present is not always possible, except in hypertrophic arthritis.

Biopsy.—As in the hip joint, biopsy is rarely employed, as the exposure of the joint requires too formidable a surgical procedure in comparison with the information obtained.

THE SPINE

The spine should be included in every routine physical examination, as nerves pass from the spinal cord through the intravertebral foramina to all parts of the body. In consequence, symptoms simulating many affections may be referred to the periphery when pathology is present in the spine. As the vertebrae are connected with the pelvis, shoulder girdle, and ribs, an alteration of the physiologic curves affects not only

the spine but the entire trunk. The routine examination of the spine is as follows:

Inspection.—If the physical condition will permit, the patient should stand with the feet approximated. The spinous processes are usually apparent and their alignment denotes the position of the vertebrae and their relations to one another. The position of each spinous process may be marked by a skin pencil, if desired. The physiologic curves are entirely in the anteroposterior direction. A convexity forward is known as lordosis, a convexity backward as kyphosis. A lateral deviation or rotation of the spine is known as scoliosis and is distinctly abnormal. The terms *kyphosis*, *lordosis* and *scoliosis* must be clearly understood for an intelligent interpretation of affections of the vertebral column. In the normal spine there is lordosis of the cervical region, kyphosis of the dorsal, lordosis of the lumbar, and kyphosis of the sacrum and coccyx. Any abnormality in the contour of the spine or trunk and unusual attitudes are quite apparent.

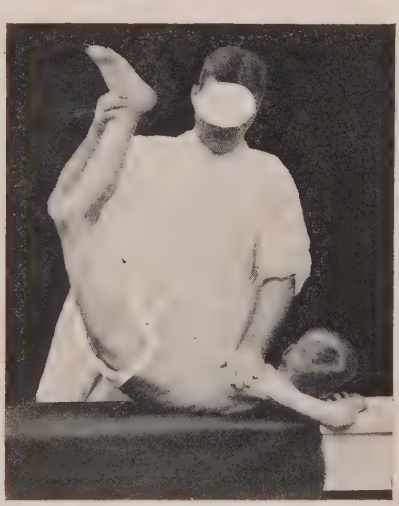


Fig. 20.—Normal range of passive extension of spine.

Palpation.—Points of tenderness are located by palpation. Deep palpation may rarely elicit irregularities not apparent by inspection, and may also confirm irregularities which have been detected by inspection. The important anatomical landmarks of the spine are the spinous processes of the seventh cervical vertebra which is always prominent and the process of the fourth lumbar vertebra which is on a level with the iliac crests.

Passive Motion.—The limits of motion in the spine have a very wide individual variation, depending on age and habits of exercise. In adults and older children, passive motion can not be elicited satisfactorily, except in the cervical region. In infants and in early childhood, passive motion provides more valuable information than active motion, as complete voluntary motion can not usually be obtained. In the cervical region normal flexion is possible until the chin touches the upper extremity of the sternum or chest. The cervical spine may be extended until the occiput approximates the upper dorsal vertebrae.

In lateral movement to either side, the ear or the side of the head will touch the shoulder. Rotation describes about half a circle, the chin approximating the anterior aspect of each shoulder.

The detection of passive motion of the dorsal spine is accomplished with difficulty, as motion is normally limited in the anteroposterior direction by the articular processes, and on either side by the attachment of the ribs. Passive motion in the dorsal spine is best demonstrated with the patient in the sitting position. The cervical spine is flexed by pressure upon the occiput until the chin touches the chest when further pressure in the same direction flexes the dorsal spine. Extension of the dorsal spine is determined in the same manner, by increasing pressure upon the forehead after fully extending the cervical spine. Lateral movement is likewise induced by further pressure upon the lateral aspect of the skull after the limit of side-bending in the cervical region has been reached. Rotation is not easily demonstrated in the dorsal vertebrae. If the condition of the patient will not permit the sitting posture, these movements may be carried out in the recumbent position.

Fig. 21.—Normal range of flexion of spine.

Fig. 22.—Normal range of active side-bending of spine.

Movement of the lumbar spine, as in the cervical region, is free in all directions. In children, flexion is elicited by placing the patient on the side with one hand upon the occiput and one hand upon the

buttocks; pressure of the hands causes, not only the lumbar, but the entire spine, to be flexed. The patient is next placed in the prone position when both ankles are grasped with one hand, while the thorax is held firmly on the examining table with the other hand placed on the posterior aspect of the dorsal spine. The lumbar spine may be extended and hyperextended by an upward lift through the ankles. Lateral bending is elicited by side movements in the same manner.

The average degree of motion can only be determined by observation and thorough knowledge of the normal. Often, on account of fear, the spine may be held rigid by contraction of the muscles, but normal motion, unless restricted by abnormal conditions, may be demonstrated by slight force in the desired direction. In examining the lumbar spine hyperextension of the hips must be tested and limitations noted, as irritation of the psoas muscle inducing contraction of the hip is often caused by affections of the spine.

Active Motion.—The demonstration of the range of spinal motion in older children and adults by passive movements is awkward and impracticable. In consequence, with the exception of motion of the cervical spine and hyperextension of the lumbar spine, passive motion may be omitted. Active motion is elicited as follows: the patient stands erect with heels placed together and the knees maintained in complete extension.

Upon request the head is moved in all directions, the range of motion being the same as demonstrated by passive motion. Voluntary motion of the dorsal and lumbar spine may be elicited at the same time. Upon request, the patient flexes the spine by bending forward. In young individuals the tip of the fingers may touch the floor. The physiologic curves are obliterated and there appears a rounded kyphos composed of the spines of the dorsal and lumbar vertebrae. Flexion of the normal spine is possible to 110 degrees which can be comprehended by observing normal individuals. Complete extension in the upright position is 180 degrees. Hyperextension is demonstrated by the examiner, fixing the hips with one hand over each trochanter and requesting the patient to bend backward. Normally the angle between the upper and lower segments of the back approximates 150 degrees. Side-bending is possible until the tips of the fingers touch the head of the fibula or below, and is about 150 degrees. The greater portion of lateral motion is carried out by the lumbar spine, but an appreciable percentage is apparent in the dorsal region. Rotation is demonstrated by stabilizing the pelvis with the hands and having the patient rotate the shoulders, but very little information is so obtained. The tendency

to bend the knee as a compensatory movement when voluntary movements of the spine are being elicited must be constantly avoided, if the degree of spinal motion is to be accurately demonstrated.

Mensuration.—Circumferential or longitudinal measurements are obviously of more practical value in a growing child, and are rarely employed in adults. Successive roentgenograms will demonstrate more clearly loss in continuity and the evolutionary process of any disease of the spine. The contour of the spine, as indicated by the spinous processes, may be demonstrated by a strip of malleable metal which is made to conform to the spinous processes. Tracings made at regular intervals of time will demonstrate changes in contour. Photographic records at intervals are also of value in recording variations due to change in contour, but the photographs must be made by artificial standardized lights under the same conditions, otherwise shadows are deceiving.

Auscultation may demonstrate clicks caused by irregularities in the joints or ligaments, but is of no practical value in eliciting definite information.

Neurological Examination.—A complete neurological examination must often be made to differentiate between affections of the spinal cord and spinal column. Quite frequently an examination of the spinal fluid is required.

Aspiration is often employed to locate abscesses in the neighborhood of or surrounding the spine, from which pus may be removed for laboratory examination.

Roentgenoscopy.—In affections of the spine, roentgenograms should be made from the base of the neck to the tip of the coccyx. When symptoms in the cervical spine are apparent, this region should be included in the examination. Two views should always be made, an anteroposterior and a side or lateral view, and in some portions of the spine views are made from other angles, since one view may demonstrate pathology which is not apparent from other angles. In the lumbosacral region a stereoscopic series is often indicated.

Biopsy is never performed in the spine solely as a diagnostic measure, but is often employed incidental to other operative procedures.

THE SHOULDER

Inspection.—The posture of the shoulder as related to the chest and spine should be noted, also its contour and size as compared with the opposite side. The relation of the head of the humerus to the acromion process of the scapula is observed, and also the relation of the clavicle to the acromion process and to the sternum.

Palpation.—On palpation any irregularities and points of tenderness must be elicited and recorded and the relations of the anatomical bony landmarks confirmed. The spine of the scapula, the acromion process and the entire upper surface of the clavicle are subcutaneous and are readily palpated. The coracoid process lies deep in the infraclavicular fossa and the head of the humerus is largely obscured by the deltoid muscle, but may be felt on deep palpation.

Passive and Active Motion.—Motion in the sternoclavicular and acromioclavicular joints consists of a sliding movement, the bony elements of the two articulations being held firmly in apposition by dense ligamentous structures. Motion in these joints usually occurs in association with movement in the shoulder joint. The range of active and passive movements of the shoulder joint proper is determined in the same manner as in the hip joint. It must be remembered, however, that the scapula moves more or less synchronously with all movements of the humerus, so that the limits of movements in the scapulohumeral articulation are not sharply defined. The synergetic combination of scapulohumeral motion with movement of the scapula on the thorax culminates in normal function of the shoulder. In fact, a fair degree of compensatory motion may be developed when there is ankylosis of the scapulohumeral joint.

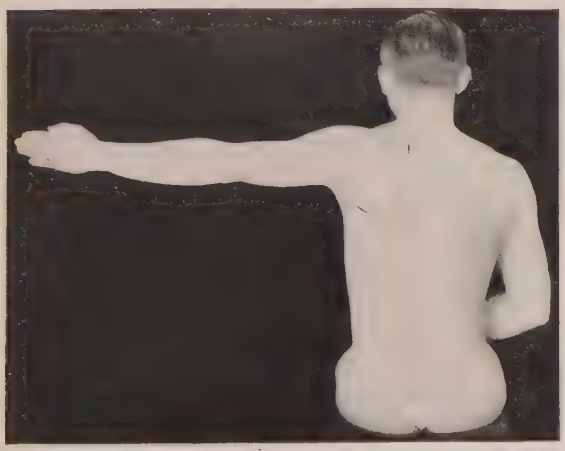


Fig. 23.—Normal range of abduction of shoulder to 90 degrees. Note position of scapula without rotation.

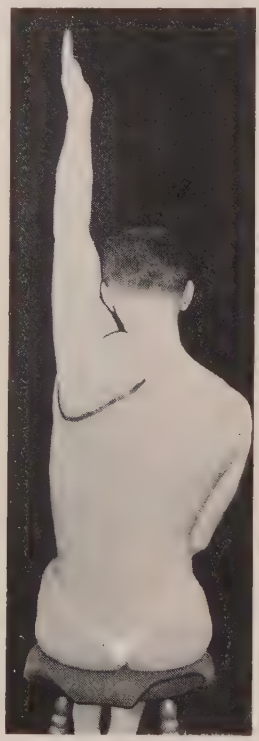


Fig. 24.—Normal range of abduction of shoulder to 0 degrees with rotation of scapula.

The shoulder may be flexed forward and upward to 50 degrees without internally rotating the humerus. Combined with internal rotation flexion proceeds to 0 degree or a straight line with the arm above the head. Extension forward and downward is possible to 180 degrees or the normal attitude with the arm by the side, and hyperextension the arm being carried backward to 120 degrees. Abduction of the arm without moving the scapula is limited at 90 degrees; abduction, including rotation of the scapula, is free to 0 degree. Adduction with the scapula is permitted to 135 degrees; internal rotation to 0 degree; and external rotation to 130 degrees. The strength of the muscle groups is determined as in the joints of the lower extremities.

Mensuration.—Measurements rarely disclose facts that are not affirmed by inspection. The length of the upper extremity may be determined by measurement from the tip of the acromion process to the tip of the styloid process of the radius; the length of the humerus from the tip of the acromion process to the external epicondyle of the humerus.

Aspiration is made when fluid is apparent, as demonstrated by fluctuation, and is often employed, as the shoulder is an accessible joint.

Roentgenoscopy.—A flat view of both shoulders is usually sufficient for the average routine examination, but when the exact location of pathology, or the relation of the bones to each other, is desired, stereoscopic roentgenograms are essential.

Biopsy may be performed to establish the diagnosis definitely, as the shoulder is quite accessible.

THE ELBOW

Inspection.—The normal anatomical contour of the elbow, as that of other joints, must be borne in mind. In the extended position, the forearm forms an angle of about 165 degrees with the upper arm due to abduction of the radius and ulna on the humerus; this angle is known as the carrying angle. The olecranon process is prominent posteriorly with the internal condyle on the inner, and the external condyle on the outer aspect; the external condyle being on a slightly lower level than the inner.

Palpation.—On palpation the normal landmarks or any change in their relation will be elicited, also swelling, luxation, irregularities in contour and points of tenderness. The normal relation of the condyles to the olecranon process must be clearly comprehended. When the elbow is extended, a line drawn from the external to the internal condyles barely touches the tip of the olecranon process. When the elbow is flexed, the olecranon is below the condyles and lines connecting the

three points form an equilateral triangle. The head of the radius lies in a depression on the postero-external aspect of the forearm where it is readily felt. Any abnormalities in relation of the parts or in contour may be observed, if not obscured by swelling. The brachial artery is palpable on the medial side of the antecubital space and the ulnar nerve is palpable in its groove behind the internal humeral condyle.

Passive Motion.—The movements of the elbow joint proper are limited to flexion and extension, but the elbow is a complicated double joint having movements in two directions. In addition to flexion and extension, rotation of the forearm at the radio-ulnar joint is an essential part of the function of the elbow. The articular surfaces are very closely approximated, and consequently, slight abnormalities

Fig. 25.—Normal range of extension of elbow to 180 degrees.

may seriously impair function. Normally, the elbow may be flexed to 30 degrees or until the anterior aspect of the forearm approximates the anterior aspect of the arm. When the elbow is in full extension the forearm is on the same plane with the arm, 180 degrees. In individuals with congenital relaxation, hyperextension of the elbow may be possible. No lateral motion exists in a normal elbow, but as in the knee, in those with congenital relaxation of joints, there may be a slight lateral play. Rotation of the forearm from full supination to full pronation forms about half a circle, during which movement the excursion of the head of the radius may be palpated. Restricted movements can be easily elicited, also crepitation or other changes in quality of normal joint action.

Active Motion.—The range of the active movements is the same as that of the passive movements and can be voluntarily instituted upon request to the patient. Restricted movements may indicate a loss of muscle power. The determination of the integrity of the triceps is important, as weakness of this muscle may be obscured by gravity extension.

Mensuration.—Measurement of the length of the upper extremity has been described in the examination of the shoulder, but the circumference of the arm and forearm should be compared at varying levels with the opposite side to denote differences in size.

Auscultation is of little practical value.

Fig. 26.—Normal range of flexion of elbow to 30 degrees.

Fig. 27.—Normal deviation of forearm at elbow to produce carrying angle.

Neurological Examination.—The neurological examination of the upper extremity includes testing of the biceps and triceps reflexes, which may be determined by striking over the tendons close to their insertions. Reflex contracture of the forearm may also be caused by tapping over the lower end of the radius. These reflexes are normal, but when greatly increased or absent, they indicate the same disease conditions as do alterations in the patellar reflex.

Aspiration should be performed when fluctuation is present. The needle should be inserted just external to the olecranon process, as the ulnar nerve may be injured when the needle is inserted on the inner aspect.

Roentgenoscopy.—Two exposures should be made of the elbow joint, an anteroposterior and a lateral. When the joint is fixed in

flexion the anteroposterior view is distorted, but at times may be obtained by placing the film about a cylinder, as described in the examination of the knee, or stereoscopic roentgenograms may be made.

Biopsy.—As the elbow is superficial and easily accessible, biopsy is indicated when the diagnosis can not be made by other methods.

THE WRIST

Inspection and Palpation.—On inspection of the wrist and hand the anatomical contour and any variation therefrom may be noted. A normal wrist is readily available for comparison by using the patient's wrist on the opposite side or the wrist of the surgeon. The styloid processes of the radius and ulna are palpable; the radial styloid normally lies at a slightly lower level than that of the ulna. The head of the ulna is prominent posteriorly and the flexor and extensor tendons of the wrist and fingers may be palpated when the muscles are contracted. The radial artery is also palpable just above the wrist.

Fig. 28.—Normal range of extension of wrist.

Passive and Active Motion.—Passive and active movements of the wrist consist of flexion, extension or dorsiflexion, adduction and abduction, and, as in the elbow, are accompanied by rotation of the forearm. The ranges of motion of the wrist joint are: flexion to 100 degrees; extension to 180 degrees; hyperextension to 120 degrees; abduction (toward the radius) to 165 degrees; and adduction (toward the ulna) to 130 degrees.

Aspiration of the wrist is best made on the posterior aspect just internal to the tendon of the extensor secundi internodii pollicis, or

on the inner aspect just below the head of the ulna, and anterior to the tendon of the extensor carpi ulnaris.

Roentgenoscopy.—Roentgenograms of the wrist must be made in two views, the anteroposterior, with the hand pronated, and the lateral view, with the wrist in the neutral position of rotation.

Fig. 29.—Normal range of flexion of wrist.

Biopsy.—The wrist, like the elbow, is superficial and easily accessible, and therefore, biopsy is indicated when the diagnosis can not be made by other methods.

THE FINGERS

Inspection and Palpation.—The anatomical contour of the fingers is determined by the same methods of comparative inspection as are employed for the wrist, and as the bones are subcutaneous, their contour as well as that of the joints, may be readily demonstrated by palpation.

Passive and Active Motion.—Passive and active movements of the fingers are limited to flexion and extension at the metacarpophalangeal and interphalangeal joints. In the thumb, beside flexion and extension, there is also a degree of rotation about the carpometacarpal joint which allows adduction of the thumb for apposition to the other four fingers. The limits of motion in the finger joints are: flexion to 90 degrees; extension to 180 degrees; hyperextension of the phalangeal joints is slight and quite variable.

Aspiration of the joints of the fingers is seldom necessary, but when indicated, may be performed by inserting the needle from the dorsal aspect, either medially or laterally to the extensor tendon.

Roentgenoscopy.—Anteroposterior roentgenograms of the fingers

are made with the hand pronated, as in the examination of the wrist. In making the lateral roentgenogram the hand is best placed in a semi-lateral position with the fingers separated, so that the shadows of the various fingers are not superimposed upon one another, or the lateral view of each finger may be made separately.

Biopsy.—The fingers being superficial and easily accessible, like the elbow and wrist, biopsy is indicated when the diagnosis can not be made by other methods.

THE BONES

Inspection and Palpation.—The technic of the examination of the shafts of long bones and the flat bones is the same as that of the joints. Inspection reveals changes in contour and other irregularities. Palpation over the subcutaneous bone surfaces may elicit points of tenderness and alteration in structural consistency. The test for intra-osseous pressure is most significant and should be thoroughly comprehended; deep, continuous pressure is made over the suspected area with the tip of the index finger. If intra-osseous pressure or tension is increased, pain will be materially augmented and is often so intense that the patient may scream in agony. Crepitation of a fractured bone is denoted by a grating sensation when the ends of the fragments are brought into contact. Comparative measurements of the long bones, as described in the examination of joints, will demonstrate an increase or decrease in length.

Roentgenoscopy.—Bones are composed of periosteum, cortex, medullary canal, the cancellous heads, and the cartilaginous articulations; any one or all of these structures may be involved in a pathologic process. The etiologic factors vary, but the pathologic changes, as demonstrated by roentgenograms, are always the same, varying only in proportion to the severity and duration of the affection. Bone destruction and bone production are the two changes in the bone apparent in the roentgenogram upon which the diagnosis is based. The relative extent of these two processes provides the basis for diagnosis. The points which should be carefully noted in the examination of all bones by the roentgenogram are: (1) The original site of the destructive process; (2) the character of the destruction; (3) the direction in which the process extends; (4) the nature and location of new bone production; (5) the condition of the periosteum, whether it is thickened, and if so, whether the layers of new bone are placed parallel or perpendicular to the shaft of the bone; (6) the condition of the bone cortex, whether it is intact, destroyed as a whole, or pierced by fenestra, expanded or unexpanded, thickened or increased in density.

When sequestra are present they are clearly visible, as their density is much greater than that of the surrounding bone. Bone tissue which has been devitalized en masse is separated from the circulatory system. The lime salts are not absorbed from necrotic bone, although the destructive process continues in the surrounding areas. The density of the sequestrum, therefore, remains normal while that of the adjacent bone is decreased. In diagnosis of bone tumors the essential point to determine is whether or not the growth is malignant. In no lesion of the bone is a knowledge of pathology more important than in bone tumors, but if the previously mentioned factors are kept in mind, the diagnosis will be greatly facilitated.

Biopsy is often indicated in bone affections, although great care must be exercised in the selection of the tissue for pathologic analysis. Thermal cauterization is required when malignancy is suspected. The laboratory technic, in decalcifying and sectioning osseous tissue, requires experience, and the interpretation of the pathologic findings can be made only by a pathologist well versed in the examination of bone tissue.

BIBLIOGRAPHY

Clark, William Arthur: A System of Joint Measurements, Jour. Orthop. Surg., 2: 687, 1920.

Cunningham, D. J.: Cunningham's Text-book of Anatomy, New York, Wm. Wood & Co., 1915.

Gaenslen, F. J.: Sacro-iliac Arthrodesis—Indications, Author's Technic and End-results, Jour. Amer. Med. Assoc., 89: 2031, 1927.

Nutter, J. Appleton: The Standardization of Joint Records, Jour. Orthop. Surg., 1: 423, 1919.

CHAPTER III

APPARATUS

The mechanical principles involved in the treatment of various orthopedic affections are practically the same. Therefore, a single complete description of the apparatus routinely and commonly employed will be given to avoid repetition and to afford a more comprehensive knowledge of the subject. Unless the apparatus is effectively constructed and intelligently applied, they may not only fail to accomplish the purpose for which they are intended, but will even produce further deformity. Various materials are employed in the manufacture of apparatus: plaster of paris, steel, sheet iron, aluminum, leather, celluloid, etc. The mechanical principles for which braces and splints are employed are as follows:

(1) Fixation to maintain position, to protect the part, and to enforce rest. Immobilization by apparatus also allays muscular spasm and relieves pain.

(2) Traction to enforce rest. Fixation and traction are used to prevent movement in the part, to allay muscular spasm or to separate inflamed or irritated joint surfaces.

(3) Prevention of deformity. Apparatus to prevent deformity must be employed continuously for a long period of time, and consequently must be so constructed as to permit ambulation when possible. Prevention of deformity may be called the keynote of orthopedic treatment.

(4) Correction of deformity. This is accomplished by apparatus so constructed as to apply gradual force in such directions as may be indicated to restore a part to the normal anatomical or most useful position.

(5) Restoration of function by gradual cultivation of motion in the joints.

Plaster of Paris.—Since plaster of paris is used more frequently than any other material in the manufacture of apparatus, it will be described first. Plaster of paris is the native sulphate of calcium made from crushed gypsum which is heated to a very high temperature to drive off all moisture, thus making an anhydrous calcium sulphate.

When water is added to plaster of paris a chemical union takes place which induces a crystallization or so-called *setting*, which is accompanied by slight expansion. Plaster of paris can be obtained readily in any community and can be adapted for immobilization of all parts of the body; however, unless of excellent quality and properly prepared and applied, its efficiency is greatly diminished.

The bandages are made by impregnating the dry powder into strips of crinoline as the bandage is rolled. To be efficient, not only must the plaster of paris and the crinoline meet certain requirements, but the actual rolling of the bandage must be done with care. The setting time of commercial plaster is too slow, requiring from fifteen to thirty minutes. This may be reduced by refining the plaster and by the addition of certain chemicals, as sulphate of potash, borax, sulphate of zinc, and common salt. Plaster of the proper quality must be secured from the manufacturer, the setting time of which should be from five to seven minutes. If the setting time is below this, a uniform cast can not be applied, and if it is above this time, the consolidation may be so prolonged that breaking occurs. No material to hasten setting should be added by the surgeon, as the hardened plaster is made very brittle, unless such additions are made in exact proportions.

Ordinary gauze may be used as the foundation for the bandage, but the best material for this purpose is crinoline of about No. 12 mesh. The crinoline should be sized or stiffened with starch; sizing with glue is not satisfactory, as the glue may not only retard, but actually prevent setting of the plaster. The crinoline can be tested for starch by inserting a strip of the material into a weak solution of iodine. If starch is present, the reaction of the iodine and starch will cause the crinoline to turn blue. If this reaction is not present, the chances are that glue or some other material is present and the material should, therefore, be discarded. No manufacturer has been able to place upon the market a satisfactory plaster bandage, due probably to the use of improper material and to rolling the bandages too tightly, as well as the chemical instability of the plaster itself. Bandages made by commercial houses are also too expensive to be practical when used in larger quantities, their usefulness being limited to short bandages for extremities, as the forearm and leg.

The bandages are made 2, 3, and 5 inches in width and from 3 to 5 yards in length. The selvedge is removed and the loose threads pulled out to prevent the edges being frayed. There are mechanical devices for the purpose of rolling bandages, but so far these have not been

found sufficiently practical for general use. The most satisfactory type is that devised by Oppenheim, which is operated electrically. Bandages must be rolled loosely and are generally best made by hand. The crinoline is torn in strips of the desired width and length. The plaster is placed on a table and rubbed into the crinoline by hand or with an ordinary school blackboard eraser. The amount of the plaster used should be sufficient to fill the interspaces of the fabric. If too much plaster is used, the finished cast will be inefficient and brittle from lack of support by the crinoline; if too little is used, the cast will be wet and soggy and will not dry. The bandage must be loosely rolled so as to permit permeation of the entire bandage by water, but must not be too loosely rolled, as the plaster will shake out in the water. In addition to the rolled plaster bandages, longitudinal reinforcements from 18 inches to 2 feet in length may be made. These are fashioned by folding the bandage in layers repeatedly at the desired lengths as the plaster is rubbed in, until six or eight thicknesses are secured, and then rolling the completed fold, which is held by a small rubber band. After the bandages are made they should be kept in a dry, air-tight metal container.

Technic.—The technic of the application of a plaster cast is as follows: The part of the body to which the cast is to be applied should be prepared by cleansing the skin with soap and water and alcohol and dusting with stearate of zinc or borated talcum powder. Stockinet or a thin layer of padding of outing flannel or sheet wadding is applied, with heavy padding over the bony prominences for protection and prevention of pressure. The padding should conform closely to the contour of the part. If sheet wadding is used, a muslin gauze bandage may be applied snugly to insure conformation. One or two gauze or muslin bandages may be placed longitudinally underneath the padding, extending beyond each extremity of the cast to be later used as scratchers. These are used to induce friction or scratch the itching skin by catching both ends of the gauze and pulling to and fro. These so-called scratches may give the greatest degree of comfort. The padding must not bind and must be free from wrinkles, knots or bumps. Irregularities of any kind may cause pressure. A sufficient amount of water to saturate all the bandages thoroughly should be on hand in deep buckets, large pans, or foot tubs; otherwise the plaster may be precipitated in the water to such an extent that partial setting occurs and further wetting of the bandages is impossible. Repeated intermissions while sending for or drawing water may cause the cast to dry in layers and thus make it weak and brittle by the

inclusion of air spaces. The bandages must be continuously applied without interruption.

Two or three plaster bandages of the desired dimension are placed in a large pan or bucket of tepid water and immersed until all air bubbles cease. This requires from two to three minutes. The bandage is grasped by both hands, one hand over each end to prevent the escape of as little plaster as possible, and lifted from the water. By slightly twisting the hands in opposite directions and at the same time bringing the hands together, so as to form a little bulge in the middle of the bandage, the excess water is expelled. The bandage should be soft and creamy, not gritty, and is applied snugly by circular turns, conforming closely to the contour of the part. Constriction at any one point must be carefully avoided, otherwise wrinkles will occur which will cause continuous pressure upon the skin with discomfort or decubitus. Bandages are applied in layers until the thickness of the cast is commensurate with efficiency and durability. The circular turns of the bandage may be strengthened by the longitudinal reinforcements which strengthen the cast without undue bulk and shorten the time of application. As needed, the reinforcements are immersed in water and placed over the points of greatest strain, being retained in position and in close coaptation by additional roller bandages. Much time is thus saved and the cast is rendered more efficient. Steel, wire, wood, or other materials are unnecessary, do not adhere to and should rarely be incorporated within a plaster cast. As each layer is applied, the bandage is rubbed firmly so as to obtain a uniform cohesion of all layers, thus greatly increasing the total strength. Radiograms of an efficiently applied cast will show a solid mass, while in an inefficiently applied cast many layers or air spaces will be apparent. As setting occurs, the cast should be molded to the bony prominences, from which support is obtained, but all direct pressure of the cast on such parts must be avoided. Until the plaster has thoroughly crystallized or set, the cast must be suspended or supported on pillows, otherwise the weight may cause indentation of the cast with continuous and serious pressure upon the skin. When a condition, as acute trauma or acute infection, is present which may induce sudden or gradual swelling, the cast should be bivalved and the segments retained by gauze bandages, so that the constriction may be released at once should pressure symptoms or interference with circulation occur.

Splints and Braces.—A splint is a temporary apparatus which may be employed to meet the requirements of fixation and support, while a brace may be classed as an ambulatory splint, which is em-

ployed for permanent or long continued use. Splints are often used as convalescent apparatus to be worn at night when the ambulatory brace is removed. Such night splints are applied more conveniently, if they are furnished with buckles and straps of webbing or leather. If, in the opinion of the surgeon or bracemaker, the apparatus is to be subjected to unusual strain, the material used should be tempered steel. Aluminum is often preferred for splints used in the treatment of fractures, because it is more permeable to the roentgen rays than other metals, and roentgenologic examination may, therefore, be made without removal of the apparatus.

Splints, plaster-of-paris casts, and braces are adapted to meet the requirements and the special conditions present in each case. In the treatment of affections of the extremities, including especially the bones and joints, with rare exceptions, the part is best maintained by apparatus in that position which will be most useful to the individual should ankylosis or restricted motion occur. This position will be called the *most serviceable position.*

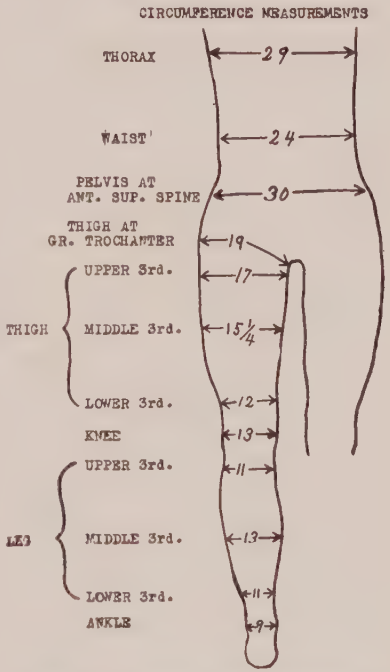


Fig. 30.—Outline of body and leg with circumferences to be used in manufacture of braces.

Braces that are to be used in the treatment of orthopedic cases must conform to the contour of the part to be supported. They must be ordered from the bracemaker with as much care as is exercised in writing a prescription to the druggist. In certain conditions, where an exact conformation is required, a plaster-of-paris model of the part must be made. A well-molded cast is applied over shirting with all padding omitted. The plaster model is removed from the part by cutting it longitudinally, after which a roller bandage holds the edges together. The model is sent to a bracemaker, who fills the shell with plaster of paris, making a form over which the desired appliance is constructed. A model is not necessary for the routine type of brace. A tracing of the limb on ordinary strong wrapping paper is sufficient. On this tracing, the location and type of the joints should be marked

and the circumferences of the regions about which circular bands and straps are to be applied must be indicated. By following this pattern the mechanic can make the apparatus conform accurately to the outline of the part.

Apparatus for each joint and part must be considered separately and for the convenience in description the same order will prevail as was followed in the description of the orthopedic examination, from below upward, beginning with the foot.

APPARATUS FOR THE FOOT

In all affections of the toes the fixed position of hyperextension of the joints should be prevented. This may be accomplished by a plaster-of-paris cast extending from the upper third of the leg to the tips of the toes. The cast must be very carefully molded to the contour of the flexed toes, or may be applied in two segments, first, from the knee to the base of the toes, holding the ankle joint at 90 degrees flexion, and when this has hardened, the section over the toes is applied while the toes are held plantar flexed. The plantar surface of the cast may be trimmed to the metatarsophalangeal junction to permit free inspection of the toes. A splint of aluminum or malleable metal also may be employed. This is made from a tracing of the sole of the foot. The splint is bent to correspond to full plantar flexion of the metatarsophalangeal joints. It is very thinly padded by a covering of adhesive plaster or gauze. A strip of adhesive about the foot and heel maintains the splint in close approximation to the sole of the foot. The toes are held in plantar flexion by a strip of adhesive about $\frac{1}{2}$ inch in width. A gauze bandage is then applied snugly about the entire foot and splint. Frequent inspection is necessary to avoid slipping of the adhesive which permits the toe to become extended or dorsally flexed; when this occurs, new strips over the dorsum of the toes must be applied.

When weight bearing is instituted after affections of the forefoot and toes, an elevation on the sole of the shoe is often necessary, just posterior to the metatarsophalangeal joints. If only one toe is involved, an elevation just posterior to the one metatarsophalangeal joint is required; when more than one toe is affected an elevation of appropriate width is necessary. A night splint, consisting of a sole plate with an elastic band attached to hold the toes in plantar flexion is often required. A splint to be placed in the shoe or a type of arch support may be worn in the day time. The feet must often be properly balanced by shoes, which are modified to meet the requirements of

the particular condition. Various types of arch supports and shoes will be described in the chapter on Static Deformities.

In inflammatory affections of the tarsal joints no appliance may be required until weight-bearing is instituted, as the strong ligaments of the foot usually maintain the small bones in proper anatomical relation. However, when there is the slightest evidence of impending deformity the longitudinal arch must be conserved and valgus or varus prevented. This can best be accomplished by a plaster-of-paris cast extending from the toes to the upper third of the leg, maintaining the foot in the desired position and at right angle to the leg. The cast may be bivalved in acute inflammatory conditions.

Splints may be employed, but the proper position of the foot is maintained in them with great difficulty. These splints are ordinary ankle splints with the foot plate attached at an angle which will maintain the foot in varus if valgus is impending, and in valgus if varus is impending. The foot is held in apposition to the splint by adhesive plaster and bandages or straps of webbing. When weight-bearing is instituted, arch supports and special shoes are adjusted to meet the requirements of the condition.

APPARATUS FOR THE ANKLE

The ankle is in such close relation to the foot that the ankle and foot are often involved in the same pathologic process or may be traumatized at the same time. In such cases, the same measures and principles are applicable as are employed for the foot, and should be instituted in conjunction with those employed for the ankle. The foot should be maintained at a right angle to the leg in affections of the ankle, though moderate equinus is the most useful position should ankylosis ensue. When the foot is maintained at a right angle, if motion persists, even to a slight degree, further movement will usually be developed by functional use and weight-bearing. Care should be taken not to permit ankylosis in too much dorsal flexion, as heel walking results in an awkward gait. However, moderate equinus to the desired degree may be permitted when ankylosis can not be prevented.

Cast.—The foot may be maintained at right angle to the leg by a plaster-of-paris cast or special splint. The cast is more comfortable and effective, when feasible, and should extend from the tips of the toes to the tibial tubercle anteriorly and to about 2 inches below the knee joint posteriorly, or to that point which will allow easy flexion of the knee.

The limb is prepared in the usual manner, after which stockinet or shirting material of suitable size is drawn over the limb from the patella to well below the toes. The bony prominences and the heel must be well padded, and the cast is then applied, being molded carefully around both malleoli. When *setting* begins, the cast is trimmed and the stockinet folded back at the upper extremity to conform to the desired length. If stockinet is not available, silence cloth or other padding may be folded in the same manner and the material held by one or two turns of bandage.

The patient will unconsciously contract the tendo achillis, and even when under an anesthetic, there is a constant tendency by the force of gravity for the foot to fall into the position of equinus. In consequence, a not uncommon error is frequently made by placing the cast on the ankle with the foot in equinus, which may cause a serious

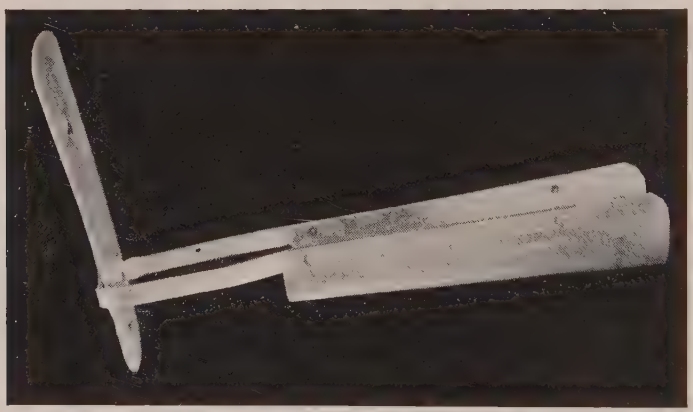


Fig. 31.—Splint to retain foot at right angle to ankle, extending from toes to just below the knee joint. Note the lateral deviation of foot piece to conform to normal relation of foot and ankle.

complication by inducing fixed contracture of the tendo achillis. The individual will be unable to place the heel upon the ground when walking begins; further deformity may be caused by compensatory varus, valgus or backward curving of the bones of the leg when weight-bearing is attempted. The leverage of this powerful heel cord must not be underestimated. All five toes must, at all times, be visible so that signs of constriction will be immediately apparent. The cast may be bivalved, the posterior half being used as a convalescent splint. When necessary either half may be removed without disturbing the position of the extremity when physiotherapy is indicated. Windows may be cut out for dressing wounds when required and if pressure

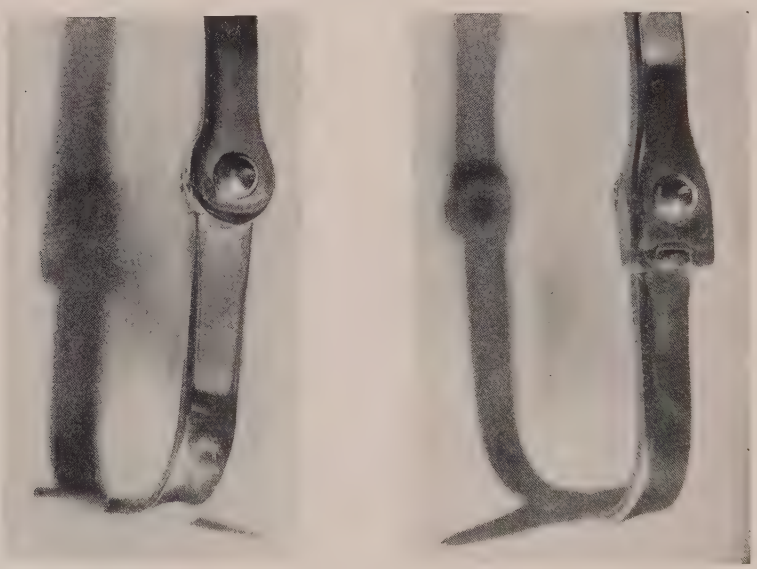
symptoms are apparent, a window should be cut until relief is obtained, but with care not to affect the mechanical support of the cast.

Splint.—Splints may be made from plaster of paris, or any material or combination of materials of sufficient strength for the purpose. The splint must extend from the tips of the toes to just below the knee, and consists of a leg piece and a foot piece. As the normal foot deviates outward at an angle of about 15 to 20 degrees in relation to the leg, the foot piece must be attached at a corresponding angle. A common error is to attach the foot piece at right angle without such deviation and, in consequence, the foot can only be maintained in approximation to the splint by placing the foot in inversion, which position is not only uncomfortable, but usually impossible to maintain. The foot piece must conform to the outline of the sole of the foot and, in some instances, to the contour of the longitudinal arch. The leg piece should be concave to conform to the contour of the posterior aspect of the calf of the leg. The foot piece should be so separated from the leg piece as to leave the heel and heel cord free from pressure. The splint is maintained by means of bandages and straps, but must be sufficiently padded. The splint routinely employed by the author consists of a gutter aluminum leg piece connected to an aluminum or steel foot piece by steel bars laterally placed, as illustrated in Fig. 31. The commercial splints on the market are made more for comfort than for efficiency, as they usually permit too much equinus and are of insufficient length; however, they are often of value as temporary measures and for transportation.

Fig. 32.—Ankle brace attached to shoe limiting plantar flexion.

Brace.—Ankle braces are indicated to permit weight-bearing and prevent deformity when a tendency to deformity still persists, to give support to a weak ankle, or weak muscle of the leg, or to permit ambulation without weight-bearing. The common ankle brace is of approximately the same dimensions and relations as the ankle splint, and consists of one or two lateral bars at the upper end of which a metal band is fastened; below, the bars are connected to a stirrup which is fastened to the sole of the shoe or a sole plate, which is placed within

the shoe. Joints so constructed as to permit movement and function in such directions and degrees as may be desirable are placed at the level of the ankle joint. No lateral movements are permitted in any type of ankle brace, as only the anteroposterior function of plantar and dorsal flexion is required. The joints may be constructed according to the following indications: (1) Without motion, but so arranged that later the desired degree or full motion may be permitted; (2) limited motion, permitting generally slight dorsal flexion of 10 to 15 degrees and no plantar flexion, thus allowing the angle between the foot and leg to be decreased, but, at the same time, preventing the equinus deformity



A B

Fig. 33.—Detail of various joints for ankle braces. (A) Free motion. (B) Limited motion.

or position; (3) permitting plantar flexion below a right angle or to any degree desired, depending upon the conditions present; (4) permitting dorsal flexion to any degree desired, but preventing plantar flexion.

There are many excellent methods and mechanical devices to meet the above mentioned requirements, the details of which depend largely upon the manufacturer of the braces. One simple system will be demonstrated which is best described by Fig. 33, A and B. Attempts have been made to adjust and refine movements of the joints by springs and elastic bands and in rare instances such special apparatus may be employed, but are seldom of practical value. Simplicity and durability are the

keynote of success in all apparatus which must be worn for long periods of time.

T-Strap.—Straps or pads are employed about the ankle to make a definite pull or pressure in certain directions to prevent lateral deviations of the foot and ankle, thus maintaining or preventing varus or valgus, according to the indications of the individual case. There are several types, but the most common, efficient and practical are the so-called varus and valgus T-straps. The varus strap is attached to the shoe with the perpendicular portion of the strap on the outer aspect of the shoe, while the transverse portion passes about the ankle and the inner bar of the brace, thus pulling the ankle inward and maintaining the foot in the valgus position. The valgus T-strap is exactly the reverse of the varus T-strap. The perpendicular portion of the strap is made so as to secure an even pressure upon the medial surface of the ankle, and holds the foot in the varus position.

Crutches are generally indicated in all affections of the lower extremities. The measurements are made from the armpit to the heel; sufficient length should always be secured, but when too long, adjustment can always be made, while if too short, they are uncomfortable or useless. Rubber tips to prevent slipping are a precaution that must always be taken. Padding of the arm support is required and, in all cases when crutches are used for a long period of time, the patient should be taught the proper distribution of weight upon the axillae and the palms of the hands through the hand pieces, otherwise crutch paralysis is not uncommon. In cases of long duration, crutches with special padding, which are more comfortable but of greater expense, can be secured from the commercial houses.

APPARATUS FOR THE KNEE

In affections of the knee, the most feasible and practical position for future function of the extremity, should ankylosis occur, is about 150 degrees flexion. Complete extension, however, is usually described as the position of choice. The reason for this is that in affections of the knee there is a constant tendency toward flexion, with external rotation and genu valgum or knock knee, which, if permitted to occur to an excessive degree, materially impairs the function of the limb in walking. Also, when the knee is held in extension, the limb would be in the best position for functional use, which in itself would stimulate increase of motion.

Buck's Extension.—Partial immobilization, correction of mild contractures, and relief of pain from muscular spasm are often accomplished

by simple traction with the well known Buck's extension, which is secured by weights and pulleys. After shaving the limb, strips of adhesive plaster about 2 inches in width are applied to the inner and outer aspect of the leg below the knee and allowed to extend loosely for about 6 inches below the sole of the foot. Circular strips of adhesive maintain the longitudinal ones in place, over which a gauze or muslin bandage is applied. A block of wood 3 by 4 inches with a hole in the center is covered by a strip of heavy canvas, the same width as the block and about 12 inches in length. The canvas is securely fastened to the block

Fig. 34.—Small wooden block with rope and pulley fixed to end of board attached to foot of bed, used in Buck's extension.

with tacks and a rope is drawn through the hole and knotted. The free ends of the canvas are attached to the free ends of the lateral adhesive strips on the leg by heavy safety pins, holding the block within 2 inches of the sole of the foot. A pulley is attached to the foot of the bed in direct line with the affected limb. The free end of the rope is passed through the pulley, and weights attached, beginning, as a rule, with about 4 pounds and gradually increasing the weight as indicated. Extension is begun in the angle of deformity, when deformity is pres-

ent; for example, if the knee is flexed at right angle, the patient is placed on a firm bed with a box of sufficient height to support the knee; pillows may at times be employed, or an over-head sling. As the knee extends the limb is lowered until full extension is secured. The pull at all times must be in a direct line with the leg and adjusted as the deformity is corrected. When no deformity is present, Buck's extension is frequently employed to allay muscle spasm and is begun in anatomical alignment. This measure is one of the simplest and most valuable and is more commonly applicable to various conditions than any other one appliance.

Cast.—The most efficient means of immobilizing the knee is by the use of a plaster cast. If complete fixation of the knee is required, particularly if the patient is excessively fat, the cast must include the hip, extending from the toes to just above the crest of the ilium. The orthopedic table or an improvised hip rest is required to apply such a cast. Generally, a cast which extends from the toes to the groin is quite sufficient. The patella and bony prominences must be well padded. Occasionally a window over the patella is indicated should pressure symptoms arise. The most frequent error in attempting to immobilize a knee is by the application of too short a cast, which neither immobilizes nor prevents deformity.

In those in whom ambulation with weight-bearing is permissible, the cast may extend from the malleoli to the groin. Slipping downward of such a cast is prevented by attaching strips of adhesive 2 inches in width to the skin of the thigh and leg, leaving the ends free for about 6 inches at the lower end. Stockinet is applied which closely conforms to the limb from ankle to groin. The padding is applied and the ends of the adhesive are turned back and incorporated into the cast with the plaster bandage.

Splint.—Immobilization of the knee may also be accomplished by posterior splints. The knee can be immobilized temporarily by a wooden splint, well padded, extending from just above the heel to the gluteal fold. As only a small percentage of limbs are entirely straight, wooden splints do not properly conform in alignment, and hence, they should be employed only as temporary measures. Splints in common usage, sold by commercial dealers, are inadequate, as they are usually too short. Each splint should be constructed to meet the requirements of the individual, but stocks of various sizes should be kept on hand, and the splint trimmed to the proper length, and adjusted to the limb by the aid of wrenches and vises when applied.

There are many types of splints made from various materials and

employed according to the individual preference of the surgeon, but three types routinely employed will be described: (1) the short knee splint which extends from just above the ankle to the gluteal fold; (2) the long knee splint which includes the foot; and (3) the gutter splint. These splints are made to conform to the shape of the normal lower extremity forming a trough, and giving firm posterior and partial lateral support. The long and short knee splints consist of a thigh piece and a calf piece of aluminum made to conform to the shape of the posterior aspect of the normal thigh and calf, which are connected by brads to two steel bars. The long knee splint is made by continuing the lateral bar below the heel, forming a loop to which a foot piece is attached by brads at the normal angle of abduction, as described in ankle splints. The ankle and knee joints are efficiently supported by the lateral bars, which also permit changes in alignment so that the splint may be adjusted to the contour of the individual patient. When perfect conformation of the splint is obtained it is padded with sheet wadding, which is retained by gauze or muslin bandages. The upper edge, terminating at the thigh and the lower edge at the ankle, should be well padded; the lateral bars should not touch the skin, and, therefore, do not require padding. The splint is applied to the limb, without undue pressure at any point, and is maintained in position by four strips of adhesive which encircle the limb and the splint. When the foot piece is employed, two strips are also passed about the foot and splint. A roller bandage of gauze, canton flannel or muslin is applied over the entire limb and splint. The simple gutter splint extends from the gluteal fold to just above the ankle and may be made of aluminum and curved to conform to the shape of the thigh and calf.

Thomas Splint.—The knee splint devised by H. O. Thomas might well be termed the universal splint for the lower extremity, as it is applicable in affections of the leg, thigh, ankle, knee, and hip. It was devised originally for traction in affections of the knee, but there are many modifications in which additional mechanical principles are applied. The splint, with minor modifications, may be employed for the purpose of fixation and fixed traction in recumbency; for fixation and stilting with and without traction as an ambulatory splint, and by the addition of lateral and anterior straps to correct deformity.

Three types of the Thomas knee splint, commonly employed, will be described: (1) the splint which is employed in recumbency, with or without traction; (2) the ambulatory splint with stilting, with or without traction; (3) the ambulatory splint for partial stilting, with fixation. The principal features of the Thomas splint are the upper

ring, which must conform closely to the contour of the groin and an inner and outer rod which are connected below by a cross bar. The ring, beginning at a point just above the greater trochanter, passes below Poupart's ligament over the anterior aspect of the thigh, closely conforms to the perineum and to the gluteal fold posteriorly and terminates at the point above the greater trochanter. The ring may be

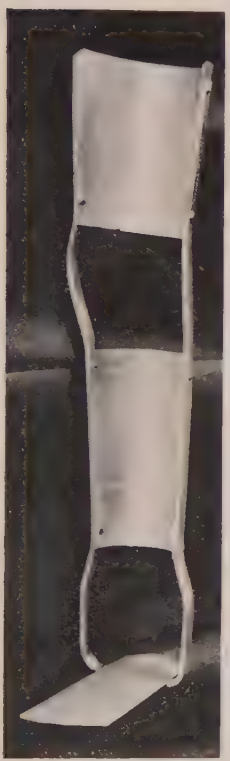


Fig. 35.—Splint to hold knee in extension and foot at right angle to leg.

Fig. 36.—Thomas knee splint.

Fig. 37.—Thomas knee splint with hinge at knee and adjustable foot plate.

flattened anteriorly over the anterior surface of the thigh, but this is not necessary, as this region gives very little fixation and no bony support. The ring is made of a cylindrical steel rod; to this ring, inner and outer flat or cylindrical steel bars are attached. The inner bar is attached to the ring at the point where the ring comes in contact with the center of the perineum. The outer bar is attached where the ring approximates the greater trochanter. The ring is thus joined to the

bars at an angle from without inward of about 45 degrees. These bars extend downward, converging to conform to the shape of the limb and are connected below by a terminal steel bar, or one continuous steel rod or bar may be attached to the ring and bent to conform to the shape of the outer, inner, and terminal bars. As traction is usually desired when the splint is applied in recumbency, the splint is made about 4 inches longer than the affected limb. Measurement of the thigh is taken for the circumference of the ring and about 2 inches is allowed for padding. The outer bar is measured from the point above the greater trochanter and the inner bar from the perineum to a point about 4 inches below the heel. The terminal bar should be made about 1 inch broader than the transverse diameter of the ankle joint. The ring is well padded with felt, over which a bandage of canton flannel may be applied, or calf skin leather may be stitched. The splint is further prepared by stitching or pinning canvas bands to the lateral rods to give posterior support to the limb.

The leg is prepared by shaving, washing with soap and water, followed by alcohol. Strips of adhesive are attached to the inner and outer aspects of the leg from a point just below the knee, but extending well below the foot for 4 or 5 inches. These strips are attached, as in applying Buck's extension, and on to the loose ends of the adhesive are rolled heavy cords or rope as one would roll a cigarette, thus leaving two loops about 12 or 18 inches in length extending below the foot.

In applying the splint, the foot is passed through the ring and the ring is pressed well up into the perineum so as to rest upon the perineum, the tuberosity of the ilium, and above the greater trochanter. Traction to the desired degree is then made upon the ropes which are tied to the terminal bar. A bandage is applied to the splint and limb, thus snugly retaining the splint in position and adding to the comfort of the patient. A foot piece may be attached to the lateral bars to retain the foot at right angle to the leg, otherwise, dorsal flexion of the foot must be made at least three times a day to prevent contracture of the tendo achillis and equinus deformity. A cloth or leather legging may be used should there be irritation of the skin by the adhesive, but this is seldom necessary.

Every physician who may be called upon to treat injuries or affections of the lower extremities should thoroughly understand the application of the Thomas splint, and should keep in stock three sizes of Thomas splints which may be employed in an emergency. The sizes of the different splints are as follows: (*a*) For children from four to eight years of age, the circumference of the ring without padding is 15 inches, the

outer bar 25 inches, the inner bar 23 inches and the terminal bar 3 inches; (*b*) for children eight to fourteen years, the circumference of the ring should be 19 inches, the outer bar 30 inches, the inner bar 28 inches, and the terminal bar $3\frac{1}{2}$ inches; (*c*) for those above fourteen years and adults the circumference of the ring should be $22\frac{1}{2}$ inches, the outer bar 39 inches, the inner bar 36 inches, and the terminal bar 4 inches. These splints are not only of value as a convenience to the physician, but proper and efficient splinting will prevent shock and reduce mortality after severe injuries of the extremities; they also facilitate and render much safer the transportation of the patient.

The splint for ambulation with stilting is of the same dimensions as that for recumbency, except that the terminal bar may be made broader and covered with leather to facilitate walking; also a bar above the

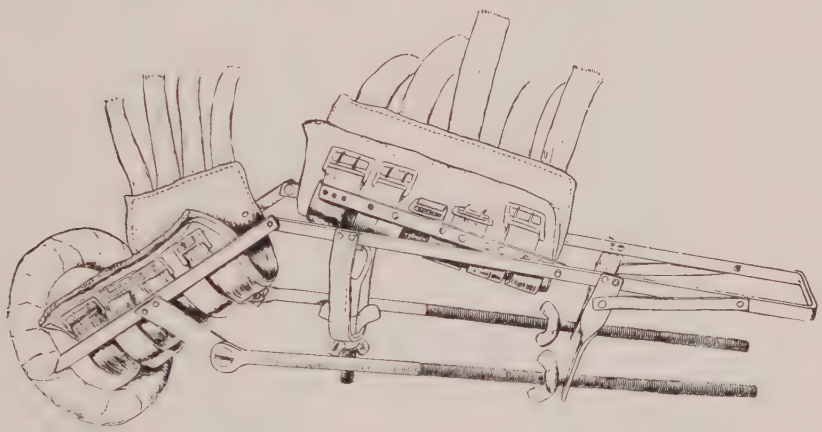


Fig. 38.—Drawing of corrective splint for correction of flexion deformity of knee.

weight-bearing bar may be required to attach traction apparatus. This may be further facilitated by a ratchet and key by which traction may be kept tense at all times. In those in whom only stilting is desired, a leather strap attached to the heel of the shoe and the terminal bar will retain the foot at right angle to the limb. Ambulation with traction is described in many text-books, but has not been found of practical value by the author. When symptoms are so acute as to require traction, recumbency is usually indicated so that traction may be kept up satisfactorily and efficiently.

Corrective Splint.—An apparatus for the gradual correction of flexion deformity of the knee has been described. The basis of this apparatus is a Sinclair modification of the Thomas splint. There is a turnbuckle to control the hinge movement in the knee by which extension or flexion

can be increased or diminished. The tendency to subluxation of the tibia, which often occurs when a contracted knee is extended, is prevented by a hinge support to the calf of the leg, which is controlled by a set-screw that makes direct pressure upon the calf and indirectly upon the upper extremity of the tibia, thus preventing any backward displacement of the tibia. Traction on the leg is made by adhesive strips fastened to the cross bar of the splint. Extension may be accomplished gradually by the turnbuckles inserted into the inner and outer bars of the splint, and at the same time pressure is made upon the upper extremity of the tibia through the set-screw.

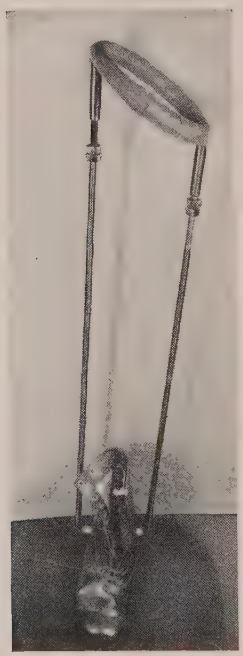


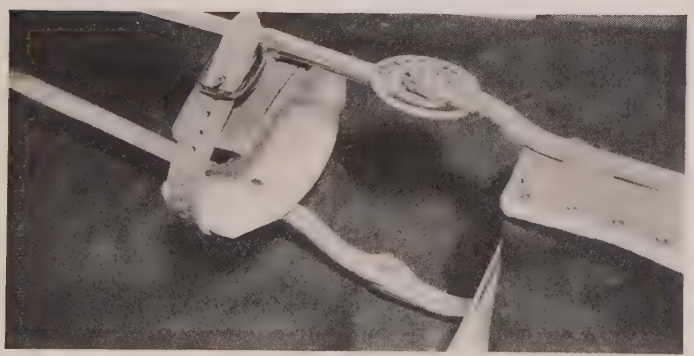
Fig. 39.—Thomas caliper brace.

Fig. 40.—Knee brace attached to shoe extending well up on thigh with elevation on shoe and pelvic band.

Brace.—The Thomas splint for ambulation with partial weight-bearing may be attached to the shoe by means of a steel stirrup with movable joint at the ankle, or preferably by a caliper joint. In the latter, the rods terminate below in a pair of calipers which fit into a tunnel of steel through the heel of the shoe. The tunnel should be placed obliquely from without inward to permit normal abduction of the foot. Adjustment of the splint to permit partial weight-bearing is

A

B



C

Fig. 41.—Detail of joints for knee braces. A, Catch to lock knee in extension. B, Stop joint to prevent hyperextension. C, Control dial to regulate range of motion by set-screw.

greatly facilitated by a turnbuckle with a lock-nut on both bars just below the ring.

Other types of braces are often employed in the treatment of affections of the knee, and in some instances to provide support to a permanently defective limb. If complete fixation is required, the apparatus must be attached to the shoe and extend as high as possible on the thigh to permit walking with comfort. The brace is constructed of inner and outer metal bars connected by broad semicircular bands, which may be covered with leather. Straps or lacings hold the apparatus in position. A short brace known as the cage knee brace is used when less complete fixation is necessary. The bars of this brace extend from the middle of the thigh to the middle of the leg, and are connected by semicircular bands and straps above and below the knee joint.

The efficiency of knee braces depends largely upon the joint, which must be constructed commensurate with the requirements of each individual case. There may be no motion or full motion permitted. There may be a locked joint in walking which permits flexion when sitting, or the joint may be so adjusted that the range of motion can be gradually increased.

APPARATUS FOR THE HIP

The most serviceable position for the hip joint, should ankylosis occur, is slight flexion, 20 degrees abduction and neutral rotation. As in the knee, ankylosis in slight flexion is more useful than in extension, but as the tendency to malposition is in this direction, complete extension should be maintained during the acute stage of all affections of this joint. The patient must remain constantly in the reclining position and at no time be permitted to assume the sitting posture. The entire body should be supported on a firm surface, such as the Bradford frame, which will be described in the section on apparatus for the spine, or boards may be placed under the mattress to prevent sagging of the bed from the weight of the pelvis.

Traction by Buck's extension may be instituted, if desired, and is applied in the same manner as for the knee joint, except that the adhesive strips on the inner and outer sides are continued upward to just below the hip joint. The traction force is applied in the position of deformity and adjustment is made to secure a continuous pull in the direction of the limb as the malposition is reduced. About 4 pounds of weight is employed at first and this gradually increased until 10 or 15 pounds are reached, or until there is muscular relaxation.

Cast.—Apparatus to immobilize the hip must extend from the nipple line to the toes on the affected side, and, in some instances, the opposite

thigh must be included. For the application of an efficient spica cast, the body and lower extremities must be supported so that complete

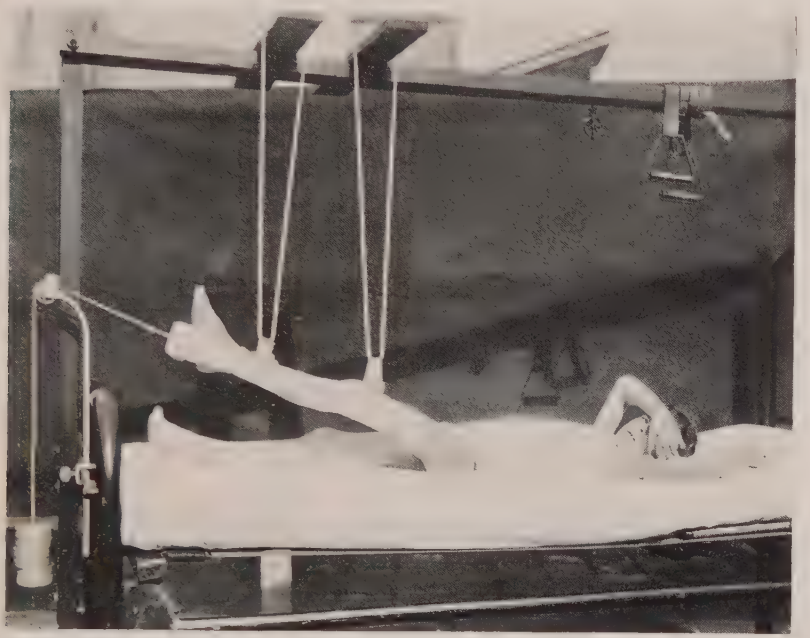


Fig. 42.—Traction in line of deformity of hip.

access to all sides of the body is secured. This is accomplished by supporting the shoulders, sacrum, and feet; an orthopedic table is desirable

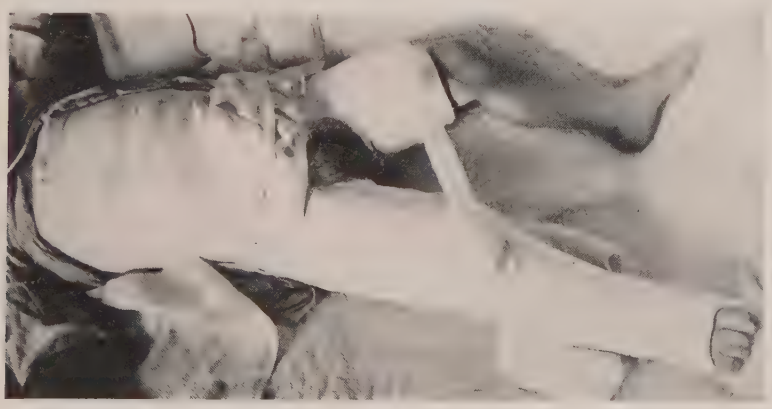


Fig. 43.—Plaster-of-paris double spica cast.

but is not always available. The shoulders may be supported by a box placed upon an ordinary table, the sacrum upon a small triangular

pedestal, known as a hip rest; however, a small can of sufficient height will make a fair substitute. The limb is held in the desired position, which depends upon the affection present. The patient is prepared by applying stockinet or a union suit from which all buttons have been removed. Special attention is given to the padding of the bony prominences, as the sacrum, iliac crests, anterior aspects of the tibiae, the malleoli, and the heels. In applying the cast, the bandages should be carried well over the anterior and posterior aspects of the hip joint and reinforcements of plaster bandage placed over the points of strain, as otherwise, breaking of the cast may be expected. The plaster should

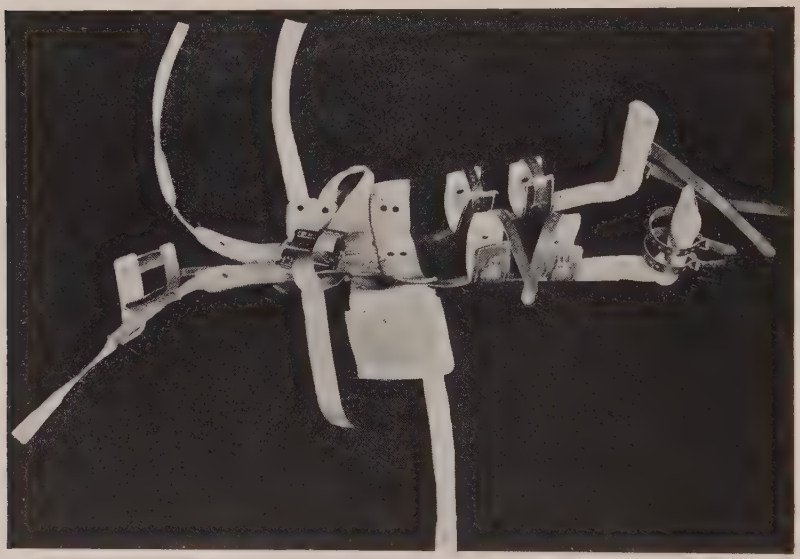


Fig. 44.—Thomas hip splint.

be carefully molded to the crests of the ilia as consolidation occurs. Depending upon indications, the cast may extend (1) from the nipple line to the toes on the affected side (the long spica), (2) from the crests of the ilia to the knee (the short spica), (3) from the nipple line to the toes on the affected side and to the knee on the opposite limb, (4) or from the nipple line to the toes on both sides (the double spica). When both legs are included a wooden bar must be incorporated between the thighs to prevent breaking of the cast by leverage.

Splint.—The Thomas hip splint or modification thereof may be employed as an appliance for fixation and retention. This consists of a steel bar extending from the scapula above to the toes below on the affected side, conforming to the contour of the posterior aspect of the

chest, loins, buttocks, and posterior surfaces of the thigh and calf, and terminating in a sole plate. Steel bands with straps and buckles

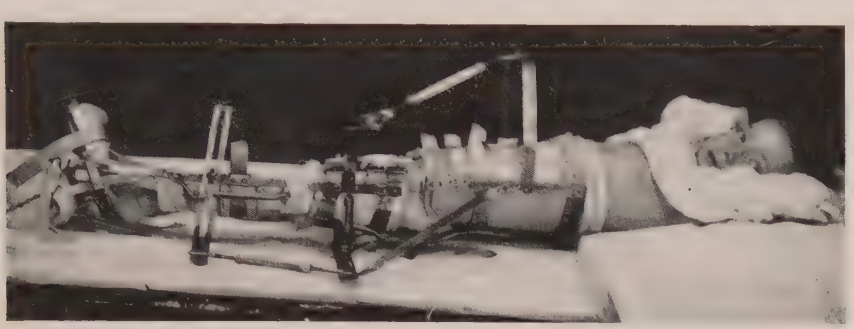


Fig. 45.—Apparatus for correction of deformity of hip with attachments for correction of flexion, abduction, and rotation.

are attached to the posterior bar. These encircle the chest, the pelvis below the iliac crests, and the upper and lower thirds of the thigh and calf. The sole plate prevents rotation of the lower extremity. In bilateral affections, a double splint of this type may be required.

Corrective Splint.—Apparatus similar to that described for contractures of the knee may also be employed for correction of contractures at the hip. In the hip joint the contractures are usually in three directions—flexion, abduction or adduction, and internal or external rotation. The apparatus, therefore, must be so constructed as to gradually apply corrective force in these three planes (Fig. 45).

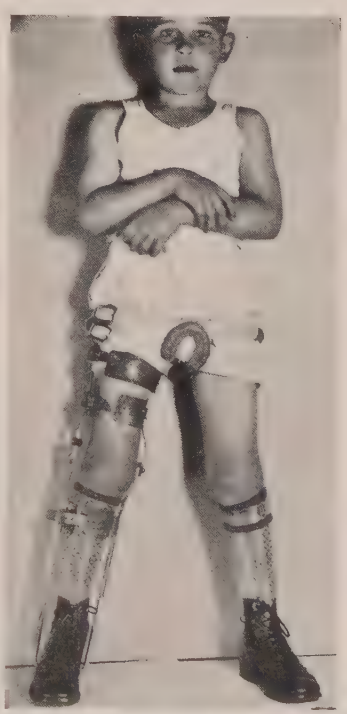


Fig. 46.—Bradford abduction hip brace.

Brace.—The Thomas caliper splint is frequently employed as a convalescent measure in affections of the hip joint, partially to prevent weight-bearing. The abduction hip splint of Bradford, which is a modification of the Thomas knee splint, is also a valuable measure in affections of the hip joint. The anterior half of the perineal ring is omitted; the other half is continued upward over the pubic bone and genitals, then downward

to the opposite groin, which it follows back to the middle of the opposite gluteal fold. This apparatus may be employed in recumbency, or as an ambulatory splint, and is applied in the same manner as the Thomas splint. For ambulation, the terminal bars of the Thomas or Bradford abduction splints are passed through a tunnel in the heel of the shoe. Joints at the knee may be incorporated to permit flexion of the knee when sitting, but so arranged as to remain rigid when the patient is walking.

APPARATUS FOR THE SACRO-ILIAC JOINT

Even though there is normally but slight movement in the sacro-iliac joint, fixation is as essential in affections of this region as in those joints of the greatest mobility. Simple rest in bed will often give temporary relief, but efficient measures give a greater opportunity for permanent relief. In acute processes, complete rest by recumbency with immobilization of the entire spine and one or both hips may be required to overcome muscular spasm and to allay pain. Hyperextension of the lumbar spine and traction to one or both legs may also be necessary. The details of mechanical treatment of the spine in recumbency applicable to this region are described in the section on apparatus for the spine, to which reference can be made.

Strapping.—Ambulatory apparatus is employed as a convalescent measure after treatment by recumbency and in mild affections of this region. For temporary relief adhesive plaster is the most efficient measure, for the application of which the patient is placed face downward with the pelvis suspended between two tables. When tables are not available, the adhesive may be applied with the patient standing.

Adhesive strips 3 inches in width and of sufficient length to extend from a line just internal to the anterior superior spine of the ilium on one side to the same point on the opposite side are prepared. The first strip is applied just above the crest of the ilium and just internal to the anterior superior spine, where it is held fixed by one hand of the surgeon. The strip is then carried across the posterior aspect of the pelvis to the same point on the opposite side. The second strip is placed below the first, overlapping the first strip about two-thirds of its width, and is started on the opposite side, the pull being made in the opposite direction as the adhesive is applied. Successive strips are thus applied until the entire pelvis, with the exception of the lower abdomen, is encased. Bulging caused by fat in this region often causes irregularity in cohesion of the adhesive which can be overcome by superimposing additional strips until there appears a firm uniform sup-

port. The adhesive dressing should be removed or changed at the end of one week. Rarely will the skin permit more than five successive strappings of this type.

Cast.—Absolute fixation that will permit ambulation can not be accomplished by a plaster-of-paris cast, but partial fixation may be sufficient, the extent of the cast depending upon the clinical symptoms. Casts may be employed simply to encircle the pelvis and crests of the ilia, with or without heavy pads over the sacrum, but such casts always require perineal straps to prevent upward displacement. A cast may be applied about the pelvis conforming to the iliac crests and extending to just above the knee on the affected side. This may be applied with the patient standing, by the use of the spinal suspension apparatus of Sayre, or by the hip rest described for the application of the spica cast. For complete immobilization, casts may be employed with the lumbar spine hyperextended to relax the lumbar muscles and should extend from the nipple line to just above the knee on one or both sides.

Belt.—A leather belt 3 inches in width is the simplest support, is more durable, cleaner and more comfortable than a cast, and should be tightly strapped just below the crests of the ilia, with or without pads over the sacrum. A simple corset with removable and adjustable pads over the sacrum, extending from the crest of the ilium to the upper extremity of the coccyx, may be made of canvas or other type of more resistant cloth. Whalebone stays and leather straps are incorporated so as to prevent wrinkling, and shoe-string lacings anteriorly and posteriorly on each side permit the apparatus to be snugly adjusted to compress the pelvis. Perineal bands, passing through rubber tubing, may be required to prevent upward displacement of the belt, or in women suspension garters may be attached to the belt and fastened below to the hose.

Often the same type of apparatus may be effectively incorporated into a low spinal brace, as partial support of the lower spine may also be required in affections of the sacro-iliac region. The same or similar apparatus may also be incorporated into the ordinary corset by a seamstress or corset-fitter.

APPARATUS FOR THE SPINE

Immobilization of each region of the spine presents a different mechanical problem. However, certain principles applicable to the entire spine will be considered with such variations as are required in the separate regions. The spine should be maintained in hyperextension, as pathologic processes in all regions more frequently invade the

bodies of the vertebrae; when there is loss in continuity of bone in the vertebral body there is a tendency toward flexion of the spine by gravity or muscular pull, resulting in kyphosis. In affections of the upper third of the spine, the weight of the head is an important factor, and apparatus for the purpose of fixation must also relieve or support the superincumbent weight of the head. In the lower lumbar spine, fixation can not always be secured without including one or both hips. The spine is immobilized in recumbency in those in whom the affection is

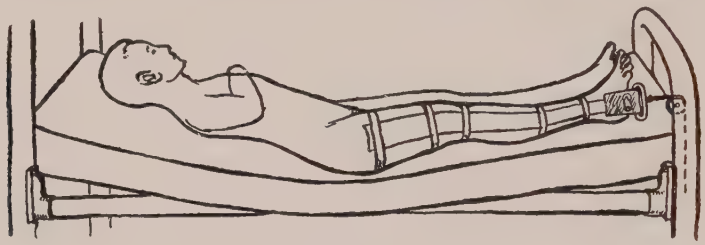


Fig. 47.—Sagging of pelvis in bed.

acute, when a destructive condition is rapidly progressing, and in infancy and early childhood when the vertebrae are of small dimension and, therefore, more easily destroyed. As the body of the young child is more or less egg shaped and the vertebral bodies are small, thus permitting more extensive and irreparable destruction from a pathologic process, complete fixation and support can only be secured by including the head and one or both thighs in the apparatus. Here complete fixation is necessary for there is impending deformity from any destructive process.

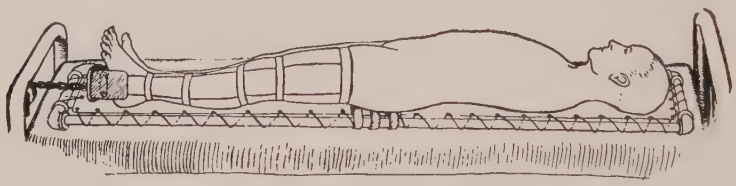


Fig. 48.—Body supported on firm surface for hip traction.

Cast.—When complete rest is desired fixation of the entire spine is necessary; a plaster-of-paris cast may be employed which includes the thighs below and the head above. A plaster bed may be made which conforms closely to the contour of the spine from the superior aspect of the head to the tip of the sacrum. The patient is placed prone upon the table; a strip of outing cloth, or other padding is cut to the desired dimensions and placed over the back. The plaster-of-paris bandages are folded, first, in a longitudinal direction, and then

transversely to cover the posterior half of the body. After setting, the cast can be removed, all rough edges trimmed and the padding adjusted and retained by adhesive plaster; it may then be reapplied and bound to the body by adhesive strips and bandages. Such a simple apparatus can be easily made, and is most efficient for the purpose of transportation or as a temporary measure. Plaster-of-paris casts have the advantage of continuous fixation, can not be changed by patient or attendant, but do not permit removal for physiotherapy and heliotherapy unless bivalved. Three types of plaster casts will be described. Modifications of these types may be made as occasion or indications demand:

(1) Plaster jacket for immobilization of the midregion of the spine (from the ninth dorsal to the second lumbar vertebrae).

(2) Plaster cast for the immobilization of the spine above the ninth dorsal vertebra, which includes a portion, or practically all of the head.

(3) Plaster cast for the lower region of the spine, which includes one or both hips.

Increase in body weight may cause the cast to become so uncomfortable as to require removal. More frequently there is atrophy of fat beneath the cast, which may decrease the efficiency of the support to such an extent as to require removal. When the patient is in the cast, care should be taken to use scratchers frequently and observe closely for any pressure sores; the odor of decaying flesh is always suggestive of decubitus; also care should be taken to prevent foreign articles falling under the cast, as they may cause discomfort and serious pressure. Not infrequently hair pins, peanut hulls, etc., are found on removal of a cast.

A cast should be removed at the end of three months as a maximum period, although the author had one cast to remain upon a patient for three and one-half years without causing deleterious effect. Casts may be used as more permanent splints by bivalving or cutting down the anterior aspect and applying some type of hooks and eyes, or straps for lacing.

There are numerous methods of application, the principles of which will be illustrated by some of the methods in common use: (1) the Sayre suspension; (2) the sling, which is greatly facilitated by the aid of an orthopedic table; (3) the hammock.

Sayre Suspension.—The principle of the Sayre suspension method is traction to the head which straightens the spine and separates the vertebrae. The apparatus required consists of a suspension halter made of heavy cloth or leather. A strip of muslin or other heavy material

about 2 feet in length and 2 or 3 inches in width is attached to each end of a wooden or steel cross bar, thus forming a loop, the center of which is placed beneath the chin with the cross bar above the head and parallel with the shoulders. Gentle traction is made upon the cross bar by an assistant, while a second strip of muslin is fastened to the loop above the ear, after which it is passed behind the occiput and attached to the loop at the same point above the opposite ear, snugly conforming to the occiput. Thus, a double sling holds the occiput and chin. The leather halter is likewise made to conform to the chin and occiput with straps on the lateral aspects, which are fastened above to the cross bar. A block and tackle is fastened to the center of the cross bar and is suspended from the ceiling or some other point overhead.

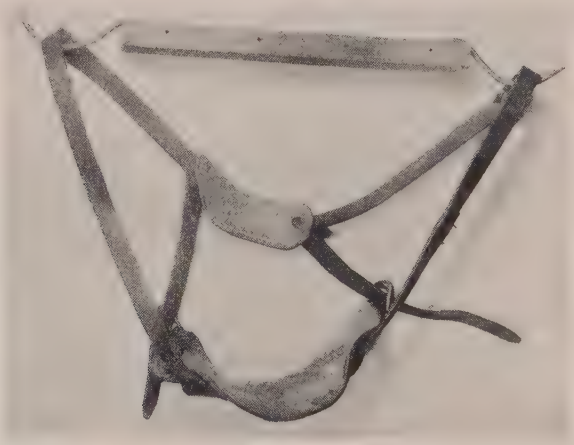


Fig. 49.—Sayre head traction apparatus.

A rectangular gas pipe or wooden frame is used in orthopedic clinics and hospitals where casts are frequently employed. The halter is adjusted to the head of the patient and traction made through the block and tackle until the patient rests only upon the balls of the feet; the heels must not touch the floor. The end of the rope is attached to a cleat at some convenient point. The upper extremities are abducted at a right angle to the body and the hands lightly grasp the lateral posts or other fixed objects.

The skin of the patient is prepared and a shirt, without buttons, is applied, or stockinet of various widths which is obtainable in bolts, is preferable. This can be cut in the required lengths, and, as it is an elastic material, conforms closely to the body. The iliac crests act as a support for the cast and must be well padded with sheet wadding,

silence cloth or felt, snugly applied so as to compress the soft tissues. Plaster-of-paris bandages are then applied, in successive layers to a thickness of about $\frac{1}{4}$ to $\frac{3}{8}$ inch, conforming to the body and molded over the crests of the ilia. The cast should extend below the trochanters. After crystallization the halter is removed and the cast trimmed. Anteriorly, the cast should extend above to the sternal notch, curving under each axilla to permit free use of the upper extremities. Posteriorly the cast is trimmed on a level with or just below the spines of the scapulae. Below, anteriorly, the cast is trimmed to the level of the symphysis pubis, on each side of which concavities are made to permit flexion of the thighs in the sitting position. Posteriorly, the cast is trimmed level with the sacrococcygeal articulation, and, laterally with the greater trochanters. The stockinet at the upper and lower ends of the cast is turned backward and fixed by additional bandages, thus retaining the padding *in situ*, and protecting the skin from the rough edges of the cast. Scratchers may be inserted, which add greatly to the comfort of the patient and are a protection to the skin. In adults an abdominal window 6 to 8 inches in diameter may be cut, if respiration is difficult, or pressure symptoms are present after eating; often windows may be required in the first casts, but not in those subsequently applied. Dinner pads, often employed, consisting of towels or other material which are removed after the plaster sets, prevent proper conformity and fixation and should never be used.

Fig. 50.—Sayre head traction and gas pipe frame for application of plaster-of-paris body cast.

When support to the upper dorsal or cervical portion of the spine is required, shirting is applied to include the head, into which holes are made for the eyes, nose, and mouth; the body, neck, and head are padded. The patient is suspended by a Sayre sling of muslin and the cast applied about the body and continued on to the neck and shoulders,

using reverse turns so as to conform to but not compress the throat. The cast extends above to the chin, maxilla and occiput, and is molded to conform closely to the neck and shoulders. After setting, the cast is trimmed so as to leave support only for the chin and occiput, with circular apertures for the upper extremities to permit free use of the arms. This type of cast is known as the Calot jacket and is efficient for support of the head. The cast may be modified, if further immobilization of the head is required, by a band of plaster about the forehead, the eyes, nose, and mouth remaining free. A simple collar may be made, or the cast may be applied so as to include the shoulders, depending upon the indications of the individual case.

Sling.—The sling method requires an orthopedic table or a cross bar attached in the center to a block and tackle and suspended from a point above. The patient is placed upon two boxes, supported on a firm table; the head and shoulders are supported on one box, the thighs on another, thus suspending the spine between the two boxes. A sling of canvas or heavy muslin from 3 to 5 inches in width is placed beneath the affected region and traction made through the block and tackle until the desired degree of hyperextension is secured. The padding and cast are then applied; after consolidation the sling is cut on both sides where it emerges from the plaster, and further plaster bandages cover up the defect. If, for any reason, head support is required in the recumbent position, a second sling may be employed about the occiput, thus supporting the head, which will permit the application of the plaster about the shoulders, neck, and head. If the hips must be included in the cast, a hip rest may be substituted for the box which supports the thighs as for application of the plaster spica.

Hammock.—The hammock method requires a rectangular gas pipe frame, with a hammock of canvas or heavy muslin attached at one end of the cross bar of the frame, and at the other to a steel rod. Ropes are attached to the rod and controlled below by a pulley and ratchet. This permits tension upon the hammock to the desired degree. The patient is placed face downward upon the hammock; tension is made by the ratchet until the desired degree of hyperextension is secured, after which the cast is applied about the hammock and patient. After consolidation of the plaster the hammock is removed or trimmed above and below. An orthopedic table greatly facilitates the application of the jacket, but the table must allow sufficient space between the shoulder support and hip rest, or be so modified as to give access to the trunk of the body.

Corrective Jacket.—Plaster-of-paris jackets are often employed for

the purpose of correcting and preventing deformity. A double hip spica cast is applied, and when the plaster has set, the cast is removed by cutting anteriorly over the chest, abdomen, and thighs. The cut edges are placed together and so retained until the cast is perfectly dry. The cast is then cut transversely at the level of the kyphos. A hinge is attached posteriorly by means of brads and two turn-buckles are attached anteriorly. The interior of the cast is well padded and the cast reapplied. By means of the turn-buckles hyperextension of the spine may be gradually secured. The procedure may be somewhat refined and a more accurate conformation obtained by making a plaster model, over which a second cast is applied.

Bradford Frame.—The most efficient apparatus in common use is the gas pipe frame with canvas cover, described by Bradford. This consists of a rectangular frame of gas pipe which can be made by a plumber, blacksmith or any one capable of using a Stilson wrench. The size of the pipe varies from $\frac{1}{4}$ inch for young children to 1 inch for adults. The required width of the frame is determined by measuring the distance between the heads of the humeri, and the length should be 12 inches more than that of the patient. For the average adult the entire

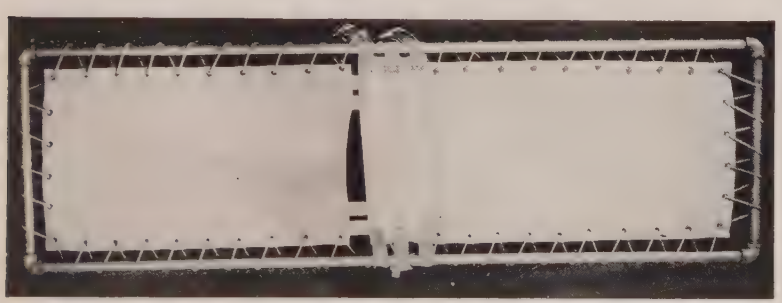


Fig. 51.—Bradford frame with slip cover for use of bed pan.

length should be about $6\frac{1}{2}$ feet, or the length which conforms to that of the average bed. Pipe of the required size and length, together with four elbows of corresponding size, is used, threads being cut by dies on each end of the pipe, but in reverse directions at opposite ends to conform to the threads in the elbows. With a Stilson wrench all parts are joined and tightly screwed together. A heavy canvas cover is made, the width of which should be about three-fourths that of the frame, and the length about 2 inches less than its longitudinal dimension. Eyelets $\frac{1}{8}$ inch in diameter should be placed along the borders of the cover. The cover is tightly laced to the frame with rope so as to give a taut, only slightly elastic surface. The frame is then padded

with a blanket, held in position by large safety pins, a sheet is applied in the same manner, and an oil cloth or rubber sheet invests the region of the buttocks and is covered by a draw sheet. The cover may be made in three segments, a long upper and long lower portion, with a narrow central segment in the region of the buttocks which permits the use of the bed pan. The frame may be supported at each end by wooden boxes, but the patient is given much greater comfort if the frame lies directly on the bed. However, the management of the patient is greatly facilitated by a system of ropes and pulleys with a control ratchet at the foot of the bed which permits elevation of the frame with the patient. Unless the segmented cover is employed, the old fashioned bed pan should be used; the modern douche pan is too high and should never be employed, as raising the patient's hips on to the higher pan defeats the purpose of immobilization and rest.

Fig. 52.—Carrell splint on Bradford frame.

In children, or adults who unconsciously turn in their sleep, restraining bands are applied over the chest, pelvis, and thighs. The simple restraining splint devised by Carrell is preferable, as it allows exposure for heliotherapy. An iron rod is bent to conform accurately to the shoulders and thighs. The apparatus is attached to the upper extremity of the frame by means of a hinge, and is fastened to a cross bar on the frame just below the perineum by means of a thumbscrew.

The management of a patient upon a Bradford frame requires careful nursing. When incompetent nurses or members of the family are in attendance they must be taught how to bathe and dress the patient; even supposedly well trained attendants require constant supervision. Daily bathing is accomplished by turning the patient with the frame on the side on to a firm surface, and then removing the frame, or the patient may be turned on the side by supporting the head, shoulders, pelvis, and lower extremities and rotating the entire body simultane-

ously; flexion and side-bending of the spine must be prevented. Lateral shifting or grasping the patient by the nape of the neck and the buttocks is a very common, but pernicious habit, which should be scrupulously avoided. Cleansing the skin frequently with alcohol and the application of dusting powder to the lower portions of the back and buttocks are necessary to prevent the formation of decubitus. The most convenient garment is a gown or night shirt, split behind; pajamas with the coat split partially behind may be used, but the trousers should be very cautiously put on to avoid too much disturbance of the patient.

Hyperextension of the spine may be secured at any desired level by strips of saddler's felt about 4 inches in width for adults and of commensurate dimensions for children. These may be inserted every few days until the desired degree of hyperextension is secured, or the Whitman modification of the frame may be made by bending the frame at the desired point so as to make a convex surface. Wallace modifies the frame for this purpose by the use of a hinged frame which is more easily adjusted to the requirements of the individual case.

Fig. 53.—Plaster-of-paris body cast including support for head.

In affections of the upper portion of the spine, head traction is always required and can be instituted by the Sayre traction apparatus. A rope is attached to the center of the cross bar and passed through a pulley attached to the bed or to the center of the upper cross bar of the frame. To the end of the rope is attached a weight which is gradually increased until the desired degree of pull is secured; 10 pounds may be necessary, though 5 pounds is usually sufficient. The weight is usually increased until muscular spasm is relieved. If there is a tendency for the patient to slide upward so that the bar approximates the pulley, thus relieving traction, the head of the bed should be elevated.

Traction may also be indicated from below, and may be applied to the legs by means of Buck's extension, as described in appliances for

the hip joint. The pulleys may be attached to the lower cross bar of the frame or to the bed in alignment with the lower extremities. Direct pelvic traction may be secured by means of pelvic girdle and straps, but extension to the extremities is usually sufficient.

For transportation, or as a temporary measure, the spine may be fairly well immobilized by strapping the patient to a padded board or employing longitudinal or transverse boards under the mattress to secure a firm, nonyielding support to the spine.

Brace.—Removable jackets of leather, celluloid or poroplastic felt may be made over a plaster model of the patient's body. Leather of suitable dimensions is soaked in hot water, stretched over the torso, and when completely dry is removed. The brace is lined with chamois skin and reinforced with steel bars about the pelvis and up the back. Hooks are placed along the anterior margins for lacing. Fenestra in the leather add to the comfort of the patient in warm climates or in the summer time. Poroplastic felt jackets are made in the same manner, but are not of common use in this country. Celluloid jackets are made by placing successive stockinet coverings over a plaster torso, and painting each layer with a solution of celluloid in acetone. The solution should be fresh and of the consistency of thick syrup or molasses; tincture of ferric chloride may be added to the solution to make the jacket noninflammable. Celluloid jackets give excellent support, but may cause irritation of the skin in warm climates.

Spinal braces must be so constructed as to give efficient fixation. Obviously apparatus may be better adapted to those in whom the bony processes are prominent, as close approximation to the skeletal outline is of mechanical value in securing fixation. Satisfactory conformation is more easily obtained in normal individuals than in short fat persons. There are many types of spinal braces employed, a majority of which are modifications of the original Taylor brace.

The Taylor spinal brace consists of two parallel steel bars, one placed on each side of the spinal column, and conforming to the contour of the back. These are fastened at the lower end to a pelvic band, and, above, about the level of the spines of the scapulae, to a short cross bar; straps are attached to the upper ends of the upright bars, and pass over the shoulders and backward to the point of origin, thus forming loops. A canvas apron covering the chest and abdomen is attached to the brace by straps and buckle at different levels, thus holding the brace in close approximation to the body. Lateral support may be added by steel plates that conform to the lateral aspect of the thorax and are connected by another transverse steel bar to the

upright bars. The pelvic band must closely conform to the pelvis below the crests of the ilia and is fastened anteriorly by buckles.

If the upper dorsal or cervical spine is affected, the head must be immobilized or supported. An attachment for this purpose may be fastened to the upper transverse bar by a steel rod. Head fixation may be secured by a steel plate which grasps the occiput. The head is held in position by a strap over the forehead. If the weight of the head on the spine is to be removed, support of the head is acquired by a circular steel attachment which conforms to the chin and occiput, and is hinged on one side to permit removal. This is connected to the brace below by a steel bar and so attached to permit adjustment in order to give constant support, and to remove the weight of the head from the spine, so that it is largely borne by the pelvis through the vertical bars and the pelvic band.

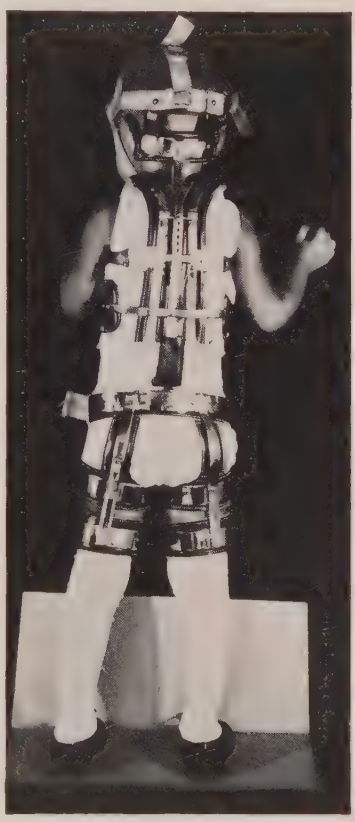


Fig. 54.—Taylor spinal brace, with author's modification, extending from occiput to knees.

In children, when complete fixation of the spine is desired, head fixation or support must be employed, and also the brace must be prolonged below to incorporate both thighs. This is accomplished by two steel bars which are attached to the pelvic band and extend down the posterior aspect of each thigh to the knee. Two metal thigh bands are fastened to each bar, one just below the buttocks and the other just above the knee. These are held in position by straps and buckles over the anterior aspect of the thigh. Support is thus given from the occiput to the knees. It is astonishing how well a child can run about and play with complete fixation of the head, spine, and both hips.

In adults, in affection of the lower lumbar or lumbosacral region, a short brace is made which extends from the pelvis to the dorsolumbar region. A sacro-iliac belt may be attached to the pelvic band and incorporated within the brace.

A jacket, such as the Knight or Steindler brace, may be made on a torso by cutting steel bars of the desired dimensions and bradding them together. Two bands are applied, one just above and one just below the crests of the ilia, encircling the anterior superior spines and affording a firm grip on the pelvis. Two strong steel bars are placed up the back; a cross band about the level of the spines of the scapulae extending under the axillae provides a firm crutch support under the arms. The foremost part of the crutch is flattened out to exert some pressure

Fig. 55.—Steindler spinal brace with lateral traction straps.

backward below the clavicle. The brace is provided in front with anterior steel bars extending down to the girdle, and to give the crutches further support a flat steel stay is run from their center to the girdled band just above the iliac crests. Straps are made anteriorly to hold the brace in position and elastic straps may be employed to make lateral pressure when desired. Such an appliance is light and efficient, and is often employed as a convalescent measure in lateral curvature.

APPARATUS FOR THE SHOULDER

There are several positions in which the shoulder may be immobilized, but generally, the most serviceable position is about 140 degrees flexion, slight internal rotation and 135 degrees abduction. Abduction is particularly indicated, as the tendency in affections of this joint is adduction with fixation of the arm against the lateral aspect of the thorax.

Cast.—Plaster-of-paris casts to the body and arm may be employed to fix the shoulder in any position desired. If fixation is indicated in one shoulder only, the cast should extend well over the iliac crests so

Fig. 56.—Plaster-of-paris body cast, extending to iliac crests for support, including arm.

Fig. 57.—Plaster-of-paris body cast, including arm, extending to costal margins and supported from opposite shoulder.

as to obtain firm support. A cast which is applied only to the upper extremity and thorax causes pressure against the lateral aspect of the chest inducing discomfort and faulty attitude. A cast which includes

only the arm and thorax should be supported from the opposite shoulder by a band crossing the base of the neck and shoulder. Support is thus secured from above on the opposite side which prevents lateral listing of the spine. The elbow and wrist should be immobilized, but the cast should not extend beyond the metacarpophalangeal joints, permitting free motion of the fingers.

Splint.—Temporary fixation of the shoulder and shaft of the humerus may be obtained by a Thomas splint, as applied to the lower extremity, or by employing an axillary pad and binding the humerus to the chest wall by a swathe of adhesive plaster, the forearm being supported in a sling. The author has devised a splint called the humerus traction

Fig. 58.—Traction humerus splint.

splint which consists of a large metal plate conforming to the lateral aspect of the thorax, and an arm piece which conforms in shape and size to the inner aspect of the arm from the axilla to the elbow. A forearm piece is connected to the arm piece at the elbow at right angle to the arm piece, to conform to the inner aspect of the forearm and hand, terminating at the midregion of the hand so as to permit free motion of all phalangeal and metacarpophalangeal joints. The forearm piece conforms to the forearm in the midposition between supination and pronation. An inner metal bar is attached to the inner surface of the arm piece and extends 3 or 4 inches below the elbow, and is then bent outward at right angle, thus giving a bar for the attachment of traction straps. The metal plate should be 6 to 8 inches in the trans-

verse diameter and 8 to 10 inches in the longitudinal for adults, and in proportion for children. For adults, the average width of the arm piece is about 3 inches and the length according to the measurement of the individual, from axilla to just below the internal condyle of the humerus. The splint is well padded and straps of webbing and buckles are attached to the thorax piece for the purpose of application.

If traction is desired, adhesive strips of suitable length are attached to the inner and outer aspects of the arm, and should extend 6 to 8 inches below the elbow, being so retained by loosely applied circular strips. The splint is placed as high as possible in the axilla, and applied slightly to the anterior aspect of the chest so as to hold the shoulder

Fig. 59.—Application of humerus splint.

semiflexed. The straps are passed about the body and opposite shoulder and fastened. Reinforcements of adhesive may be applied to fix the thorax piece and to secure the splint firmly in the axilla. Traction is then made upon the adhesive strips on the arm, which are fastened to the traction bar. The volar or anterior aspect of the forearm is placed against the forearm piece and retained by strips of adhesive. A roller bandage of gauze or muslin is then wrapped about the entire upper extremity.

This splint was originally devised for fracture of the upper end of the humerus, but has been found to be of great value in many other abnormalities and injuries of the upper extremity. Modifications have been made for lesions of the lower segments of the humerus, the elbow,

and forearm. The forearm piece[1] may be attached to the arm piece to permit controlled rotation of the forearm, and to fix the forearm in any desired position from extreme supination to extreme pronation. A loop of wire may be attached to the forearm piece extending well below the hand to allow attachment of adhesive strips on the forearm for the purpose of traction. When the circular wire is added a flange is attached to the arm piece which passes over the anterior aspect of the arm to permit a fulcrum for countertraction. This splint is useful for most of the lesions of the upper extremity; it permits ambulation with traction, and may also be employed for simple fixation without traction, if the traction bar is removed or omitted. Thus, clothing may be worn, as the sleeve can be passed over the splint.

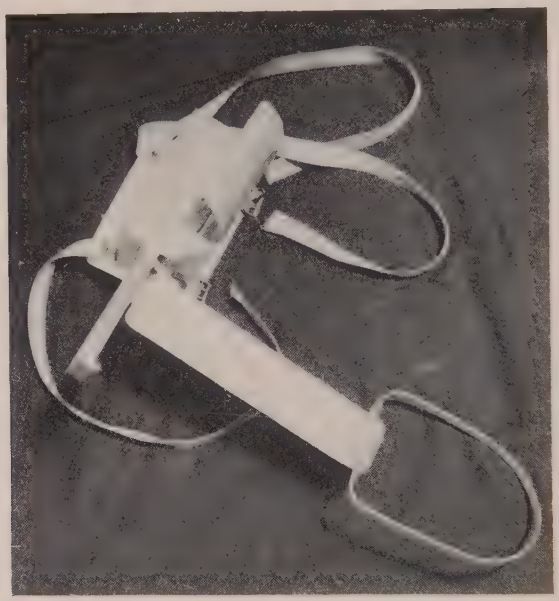


Fig. 60.—Modification of traction humerus splint, with flange about upper arm and loop extending from forearm piece.

A modification of the Thomas splint, devised by Jones, is commonly employed and consists of an upper ring with lateral bars to conform to the arm and forearm with the elbow flexed at right angle and the lateral bars forming loops below the elbow to permit traction. The shoulder may also be held in abduction by a splint which consists of a chest piece, an arm piece, and forearm piece which conforms to the

[1] The arm, forearm, and chest parts of this splint were devised by Henderson as a convalescent measure. The other portions of the apparatus were added by the author to maintain fixed traction and approximation of fragments.

lateral aspect of the chest, posterior aspect of the arm and forearm. This is padded and attached by straps and adhesive plaster.

The aeroplane splint, used extensively during the World War in the treatment of injuries to the upper arm and shoulder joint, was designed to maintain abduction of the arm. It is constructed of heavy steel wire or bands which are bent to conform to the contour of the thorax and upper extremity in the desired degree of abduction, usually 90 degrees. Heavy muslin or canvas strips are fastened to the splint, as illustrated in preparing the Thomas splint, and the apparatus is then secured to the body by straps or bandages. Shoulder braces and corsets of leather, which include the arm, shoulder, and chest, or include only the arm and shoulder, may be attached by straps. Such apparatus are not particularly successful, as it is difficult to immobilize the shoulder by such measures, but they may be employed for joint fixation or support. Splints and apparatus for the sternoclavicular joint and clavicle will be described under fractures of these regions.

APPARATUS FOR THE ELBOW

The most serviceable position for an elbow is that which places the forearm at slightly less than right angle to the arm, with the forearm in supination or in the midposition between supination and pronation. A plaster cast for immobilizing the elbow in this position should extend from the metacarpophalangeal joints to as high in the axilla as is possible or consistent with the comfort of the patient. The cast may be bivalved or the posterior half may be used as a splint.

Splint.—Splints conforming to the anterior or posterior surfaces of the extremity may be employed, but the posterior splint is more efficient and comfortable. This apparatus consists of an arm and forearm piece conforming to the posterior surfaces of the hand, forearm, and arm from the metacarpophalangeal joints to a point on the arm at a level with the posterior axillary fold. As the forearm normally is in the position of about 15 degrees valgus as related to the arm, the forearm piece on the splint must be joined to the arm piece at a corresponding angle.

A right angle elbow splint conforming to the inner aspect of the arm, and the volar aspect of the forearm, and terminating at the middle of the palm, is more often employed for lesions of the forearm than the elbow. In this splint the forearm is maintained in the midposition of supination.

A simple splint for enforcing supination of the forearm has been described by Funsten. It consists of an inner bar of $\frac{3}{16}$ inch steel ex-

tending along the inner side of the arm and forearm from the axilla to the palm of the hand, being bent at the elbow to 90 degrees. The palm of the hand offers the most durable point distally, and here an oval band, through which the four fingers are thrust, is employed. Another band with a strap is applied just above the wrist joint to steady the brace and prevent rubbing. The arm above the elbow is held securely by two circular bands, one at the upper extremity of the splint and the other as close to the elbow joint as possible. In applying the brace the distal band is first slipped over the fingers on to the palm of the hand.

Fig. 61.—Splints used for support of elbow and wrist.

The inner bar is then approximated to the arm as the forearm and hand are supinated, the required amount of supination being thus maintained at will. This brace is very useful in pronation contractures, and also maintains the wrist in a hyperextended position.

Braces.—Braces for the elbow may be made with lateral bars of steel, which are connected by metal bands and fastened by straps and buckles, as in braces for the lower extremities. The arm and forearm may, if desired, be encased in corsets of leather attached to the braces. Braces are often employed with hinges at the elbow to limit or restrict flexion and extension between certain ranges. These joints may be fixed with catches to permit motion as desired.

APPARATUS FOR THE WRIST AND FINGERS

The most serviceable position for the wrist joint is extension or dorsiflexion, for in affections of this joint there is an ever-present tendency toward palmar flexion and luxation. Plaster casts may be employed to prevent this deformity, or a simple splint made of sheet metal, called

Fig. 62.—Banjo splint.

the cock-up splint, may also be used. This splint should extend from the middle of the palm to the upper third of the forearm. A notch should be cut over the palm to allow for the adducted position of the thumb and the thenar eminence. At the wrist joint the splint is bent back-

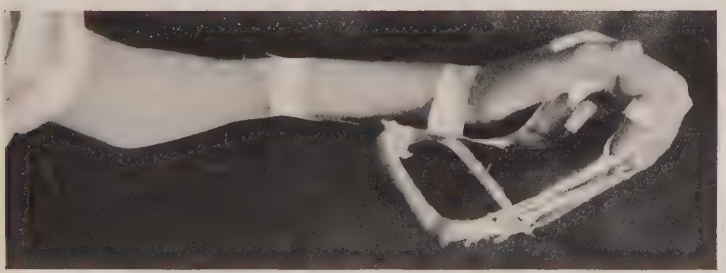


Fig. 63.—Reverse banjo splint.

ward or cocked up, to hold the hand in the desired degree of dorsiflexion or extension.

Simple splints for immobilization of the individual fingers or for correction of deformities and contractions of one or more fingers may

be made of aluminum, tin, or wood. Such splints are constructed by making a tracing of the forearm, hand and affected fingers on strong wrapping paper, transferring this pattern to sheet aluminum or other metal, and cutting the splint to the desired dimensions. A tracing of the opposite hand may be used if the affected hand is severely contracted. If traction is desired, the splint may be prolonged beyond the tip of the finger and traction applied by a rubber band fastened to the finger with adhesive plaster, or fastened through a hole drilled in the fingernail.

A splint, known as the banjo splint, may be employed to correct contractions of the wrist and fingers and consists of a cock-up splint, to which is attached a metal loop. Traction to the fingers is applied by rubber bands and adhesive tape. In the event that the fingers are extended and it is desired to secure flexion of the joints, the position of the metal loop may be reversed and traction made in the opposite direction.

Braces for the wrists are usually applied for the purpose of complete immobilization. Joints are practically never required. Leather corsets, reinforced with steel bars, are the most satisfactory apparatus and must be constructed over a plaster-of-paris model as are spinal jackets. In all apparatus for the upper extremity, except in affections of the fingers, it cannot be too strongly emphasized that the fingers must remain free. The splints should not project beyond the metacarpophalangeal joints, leaving these joints as well as the interphalangeal joints a free range of motion so that a fist can be made. Repeated and frequent active motion of the fingers should also be encouraged.

APPARATUS FOR INDUCING MOBILIZATION

Special apparatus for inducing gradual restoration of motion in various joints may be employed when there is impaired motion or a limited range of motion. The apparatus may be successfully constructed for the ankle, knee, hip, elbow, and wrist joints, but will be described and illustrated for the knee and hip only.

The Knee.—The appliance for the knee consists of a Thomas splint with a foot plate for supporting the ankle at right angle to the leg. The splint is hinged at the knee, straps and buckles are applied for firm immobilization of the thigh and leg and the portion encircling the thigh mounted upon a pedestal or supported by four legs as a base. Weights are attached to the foot of the splint and a rope running from the foot piece to the patient's hand is carried through a system of pulleys fastened to an upright bar. The weights cause flexion of the knee by gravity and the patient extends the joint by traction on the rope.

The Hip.—The apparatus for the hip is similar to that for the knee, but the entire spine, pelvis, and opposite limb must be immobilized.

Fig. 64.—Mobilizing apparatus for knee with knee extended.

Fig. 65.—Same as Fig. 64 with knee flexed.

A splint similar to a Thomas hip splint is constructed with a joint at the hip on the affected side allowing free range of motion. The trunk

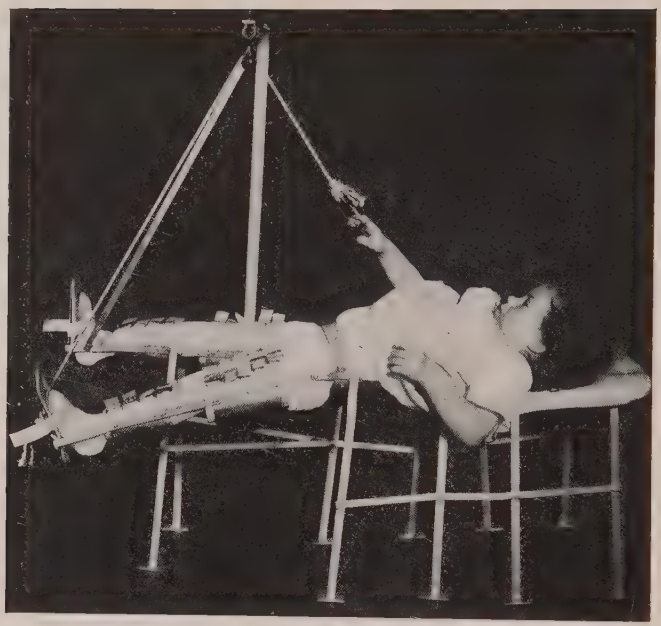


Fig. 66.—Photograph of mobilizing apparatus for hip with joint extended.

Fig. 67.—Same as Fig. 66 with hip flexed.

and limbs are fastened securely by straps and buckles. A weight may be fastened to the foot of the splint or the weight of the limb alone may be sufficient to produce extension and hyperextension of the joint. Flexion is made by pulling on a rope which is fastened to the foot and passes through a pulley on an overhead frame.

SYMPTOMS OF CONSTRICTION FROM APPARATUS

After the application of any apparatus, splint, brace or cast to an extremity for an acute condition, as trauma, infection, or following an operation, the patient must be carefully observed for symptoms of pressure or constriction. When splints have been applied to the upper or lower extremity, the fingers and toes respectively should be under constant surveillance until all danger of pressure induced by swelling from an acute reaction has passed. This requires from three to four days, and in some instances, if symptoms persist, a week. The crucial period when serious pressure complications are more apt to occur is within the second twenty-four hours, usually the second night after the irritating trauma or manipulation; as a rule, there is not sufficient reaction to cause severe pressure during the first twenty-four hours. There are a few cardinal signs of great significance which should be known to every physician and nurse or attendant: (1) Pain, extreme or excruciating; (2) color, cyanosis, anemia or blanching; (3) swelling; (4) depressed local temperature; (5) diminished sensation; (6) loss of motion; (7) sudden elevation of temperature which cannot be otherwise accounted for.

Intense continuous pain may rarely occur in the clinical course of certain affections; most patients complain, and some more than others, but continuous pain in one locality should be investigated. If inspection is made, the possibility of a serious complication from pressure can be excluded. Cyanosis is an indication of venous stasis, usually a result of superficial pressure, caused by a crease in the padding or indentation of the cast. Anemia, or sudden blanching, indicates impairment of the arterial circulation, possibly a thrombosis, which is of extremely serious consequence. Swelling and depressed local temperature are of significance only when associated with other signs. Diminished sensation, if slight, is not significant, but complete loss usually indicates serious nerve impairment, especially if associated with loss of motion, provided, of course, that function previously existed. Diligent and constant care should be given by a competent attendant, who should notify the physician at once when any of these signs are observed. If constriction is recognized, a portion of the splint or cast should be

removed at once to permit inspection. If no improvement occurs, the entire apparatus must be removed and the position of the limb changed. Undoubtedly, if careful management is carried out in every case, many serious complications with permanent impairment would be averted and many limbs saved that are uselessly sacrificed.

BIBLIOGRAPHY

Campbell, Willis C., and Mitchner, J. M.: An Apparatus for the Correction of Flexion Contracture of the Knee, Jour. Bone and Joint Surg., 8 : 416, 1926.

Funsten, Robert V.: Suggestions from the Brace Shop, Jour. Orthop. Surg., 2 : 345, 1920.

Taylor, Charles Fayette: The Spinal Assistant, Trans. Amer. Orthop. Assoc., 12 : 15, 1899.

Wallace, James O.: Crush Fractures of the Spine, Jour. Bone and Joint Surg., 5 : 28, 1923.

AFFECTIONS OF THE JOINTS

CHAPTER IV

ACUTE AFFECTIONS OF JOINTS

ACUTE INFECTIOUS ARTHRITIS

According to the classification given in Chapter I, the affections of joints will be first described. Acute infectious arthritis is the most frequent of the destructive diseases occurring in joints, although the impression prevails that the most common cause of permanent disability as a result of joint disease is tuberculosis. In an analysis of the author's records, the ratio of pyogenic infection to tuberculosis was found to be about two to one. The distribution may be confined to one joint, as a monarticular infection, or extend to two or more joints, as a polyarticular infection. A general description of the process will first be given as occurring in any joint, after which special consideration will be given to the individual joints.

Etiology.—Acute infectious arthritis is an acute inflammation caused by the invasion of a joint by any of the pyogenic bacteria, as staphylococcus, streptococcus, gonococcus, pneumococcus, and meningococcus. The infection is derived chiefly through the blood stream from infected foci, as teeth, accessory sinuses of the nose, nasopharynx, tonsils, furuncle of the skin, genito-urinary tract; or, by penetration from without as gunshot wounds, from within as compound fractures, and by continuity from infections in close proximity to the joint. The process is often a sequela of an acute infectious disease, such as measles, scarlet fever, pneumonia, meningitis, and smallpox. Arthritis, induced by any one of the pyogenic bacteria, is often described as a separate clinical entity, but the pathology, symptoms, and physical signs are so closely related as to warrant the inclusion of all types in one description.

Pathology.—An acute reaction, evidenced by the formation of an effusion within the joint, is induced by the pyogenic organisms; this effusion may be serous, seropurulent, or purulent, depending upon the virulence of the infection and the resistance of the tissues. The pathologic picture is one of an acute inflammatory process—an active hyperemia of the synovia and intra-articular structures with infiltration

usually limited by the capsule, but at times extending to the periarticular tissues. If virulent necrosis ensues with adhesions and fibrosis, there will be further organization into tough fibrous tissue, fibrocartilage or solid bone. In serous exudates there is rarely extensive destruction, and the joint usually returns to normal. In seropurulent exudates the process is more severe and may result in extensive adhesions of the articular surfaces. In purulent exudates, especially if virulent, evidenced by the formation of thick pus, the articular structures may be completely destroyed. There is found in the exudate of pyogenic organisms a proteolytic ferment, or enzyme, which has a selective and digestive action on the cartilage and synovia. This may be demonstrated *in vitro* by placing strips of cartilage in pus. The cartilage is usually first invaded at the point of greatest contact, and this invasion may progress until the entire articular surface is effaced. In children, the bone is invaded for a greater distance than in adults, evidenced in the roentgenogram by hypertrophic changes in the shaft of the bone, but there is less actual osseous destruction in children, due probably to the inherent difference in structural quality. Sequestration rarely occurs, except in those joints in which the capsule includes a large area of adjacent bone, unless an osteomyelitis invades by continuity. In children, partial or complete obliteration of the epiphyses is not uncommon; if partial, future growth will be irregular; if complete, growth is arrested, but may be later compensated to some extent by hyperactivity of other epiphyses in the affected extremity. When the periarticular structures are involved in the inflammatory process, there may be contracture of the muscles, tendons, and ligaments surrounding the joint, with the formation of dense adhesions. Rarely, the purulent exudate may extend into the periarticular soft structures, and after incision into the joint, a diffuse cellulitis is not uncommon. There may be a return to normal following the subsidence of the process, or the joint may be more or less impaired. Ankylosis in those under eight years of age is usually of the fibrous type, and a return of function is to be expected if contractures are prevented. Above this age, bony ankylosis occurs with increasing frequency in direct proportion as age advances. In neglected cases, contractures of ligaments and periarticular structures, with malposition, distortion, subluxation or complete dislocation, are of frequent occurrence.

Symptoms.—The clinical course is definite and may be divided into three stages: (1) Febrile or acute stage which lasts from four to eight weeks; (2) the subacute stage in which there is pain and tenderness persisting over a period of several months, or very rarely, is indefinitely

continued with progressive invasion of other joints; in fact, becoming a low-grade type of progressive infectious arthritis; (3) the stage of residual impairment, which in reality is the terminal result after the subsidence of the pathologic process.

Acute Stage.—The onset is sudden, with high temperature and all the classical symptoms of a pyogenic infection or sepsis. A history of trauma is often elicited, but this may be either a coincidence or a predisposing factor. A chill in adults or a convulsion in children may be the first symptom, or rarely slight soreness or pain may have existed for a few days. The affected joint is enlarged by increase in articular fluid. Fluctuation, local heat, and redness are apparent in superficial joints, such as the knee. Pain is in direct proportion to the increased tension within the joint. Tenderness is exquisite, being often exaggerated at one or more points. The joint is held in the most comfortable attitude, which may be termed the neutral position, that is, the position where articular pressure is least and muscle relaxation greatest. Unfortunately, the neutral position is usually flexion, or flexion combined with some other position as abduction, and if permanent, is a serious disability. Active motion is restricted and may not be possible on account of pain. Passive motion is usually possible, but limited. The symptoms may be confined to one joint or may appear successively in many joints, but in polyarticular invasion the same degree of intensity of the process is rarely concurrent, one or two joints being more severely affected than others. After a period of four to eight weeks, depending upon the virulence of the infection and the resistance of the individual, the infection subsides, the constitutional symptoms gradually disappear, and the second or subacute stage begins.

Subacute Stage.—The subacute stage may be considered the stage of resolution and lasts from two to four months, sometimes longer, during which time the joint is painful and swelling of an indurated nature persists. On palpation local heat is observed, and there is usually definite tenderness about the joint, which may be exaggerated at certain points where the infection has been most intense. Active and passive motion are more or less restricted, depending upon the virulence of the infection. Unless preventive measures are instituted, malposition and extreme deformity may result. The pain may continue indefinitely, or may be entirely absent except when the joint is moved, depending to some extent upon the type of infection. For example, in gonorrheal infections, the subacute stage is markedly prolonged, and continued pain and tenderness exist for months or until ankylosis ensues. As the local symptoms subside the joint either returns to

normal or there may be organic changes which may cause total or partial loss of function, with fibrous or bony ankylosis, or rarely the process may become a low-grade infection with progressive invasion of other joints.

Stage of Residual Impairment.—In the third, or residual stage of impairment, the active process having ceased from one to many years, the condition is a status, not a pathologic entity—just as is the scar of an ancient burn. If resolution of the pathologic process during the subacute stage is complete and the joint restored to normal, the third stage is never reached. The infection may be dormant for many years, but may become relighted following trauma or surgical procedure. In this stage there is often a change in the structure of the bones composing the articulation, evidenced by hypertrophy and increased density shown by the roentgenogram. Changes in the relation of the articular surfaces caused by malpositions and distortions may also occur and fibrous or osseous ankylosis is frequently observed. Pain on active use from irregularity of joint surfaces due to deformity, scar tissue, or intra-articular and extra-articular adhesions may be present or there may be no subjective symptoms.

Laboratory and Roentgenological Examination.—In the febrile stage, and so long as the infecting organisms are active, the blood shows the characteristic reaction of an acute infection, by a total increase in the white cells and a relative increase in the polymorphonuclear neutrophils. After several weeks' duration of the acute stage, there may be a decrease in hemoglobin and in the number of red blood cells. This secondary anemia may also persist into the early part of the subacute stage. For two or three weeks after the onset the roentgenogram furnishes no information which cannot be elicited by physical examination. The first apparent sign is a mottling of the cavernous bone adjacent to the joint, evidenced by light and dark areas for a short distance beneath the articular cartilage. This appearance is largely due to osteoporosis or bone atrophy. Later, unless the process is arrested, there will be a gradual decrease in width of the joint space. After further destruction, obliteration with adhesions of articular surfaces, denoted by a line of cleavage in fibrous ankylosis occurs; or, if the articular surfaces are completely destroyed, there will be approximation of the bony surfaces, a precursor of osseous fusion or ankylosis. Solid osseous fusion does not occur for several months, or sometimes a year. Complete dislocation, especially of the hip joint from distention of the capsule, may be rather an early manifestation. Atrophic changes may be seen for a considerable distance in the shafts of the bones on both sides of the

joint during the subacute stage. Osteomyelitis, usually of mild degree, may develop along the shaft of the bone by direct continuity of the infection, evidenced by periosteal proliferation, but sequestra are rarely apparent. Coincidently with resolution there will be a gradual increase in density, and at times in the dimensions of the bones, which gives a massive clear-cut appearance that remains permanently.

Diagnosis.—In the acute stage, the diagnosis may be apparent from the symptoms, but differentiation must be made between primary osteomyelitis and arthritis. In osteomyelitis the extreme localized tenderness, which is deep seated over the bone, is an important diagnostic factor. There may be swelling and limited motion of the adjacent joints in osteomyelitis, but in acute arthritis the joint symptoms are exaggerated. Aspiration of the joint, with laboratory examination of the fluid, will be an aid to differential diagnosis. Differentiation must also be made from periarticular affections. In periarticular affections, such as acute bursitis and inflammation along the tendon sheaths, the points of tenderness are definitely localized over the affected structures. A knowledge of the anatomical position of the bursae and their relations and communications with the joint cavity is most essential. Palpation will indicate induration and a localized tumor surrounding the joint which is acutely tender on pressure. Motion of the joint is restricted only in those directions which cause increased pressure or tension within the diseased structure. Motion in all other directions is free, which is an important point in differentiating such lesions from acute arthritis.

In the subacute stage, where there is polyarticular involvement, the affection may closely resemble low-grade infectious arthritis or the progressive polyarticular type of arthritis, but the differentiation can be made from the history of the onset. In the subacute stage of monarticular arthritis, the erroneous diagnosis of tuberculosis is far too frequently made, with the employment of measures which are often contraindicated and deleterious. The opinion prevails that a debilitated condition exists from the onset of tuberculosis in joints, when, in fact, the general health is usually excellent; whereas, following the acute stage of an acute infectious arthritis, the patient always presents evidence of a recent severe illness. If the history is not obtainable, the roentgenogram will clearly differentiate the two conditions. In the subacute stage of acute infectious arthritis, after six weeks, the roentgenogram reveals a mottling of bone in proximity to the joints, with destructive changes from within which is unmistakable. In tuberculosis, at the end of six weeks and often as long as six months, there

may be no visible manifestations in the roentgenogram except general atrophy. When destruction is observed in tuberculosis, the process is active beneath the incrusting cartilage, which appears to be undermined, while in acute infectious arthritis the erosion is first seen on the superficial surface of the cartilage.

In the stage of residual impairment, diagnosis may be difficult, for the active process may have occurred so early in life that no detailed account can be secured. Differentiation from tuberculosis must be made, for when tuberculosis has been the etiologic factor, surgical measures within the joint must be avoided if possible, though mechanical advantages may be gained thereby. But, if the etiologic factor has been one of the pyogenic organisms, radical surgery within the joint, when indicated, may be employed with impunity. If the history is not dependable, the roentgenogram is the only source of information, for the residual malposition and deformities of acute infectious arthritis and tuberculosis are practically identical in appearance. In tuberculosis, not contaminated by secondary infection, differentiation by the roentgenogram is not difficult. Atrophy is more extensive with slight or no hypertrophic changes, and the joint line is usually visible by a complete or irregular dark zone designating an area of former destruction or encapsulated tuberculous detritus. When acute infectious arthritis has been the causative agent, there is slight, if any, atrophy. Hypertrophy with increase in density is present, and complete loss of joint space with organization and solid bony fusion is not infrequently encountered. In those in whom tuberculosis is complicated by a secondary pyogenic infection an accurate diagnosis may be difficult, but differentiation may be made in the greater proportion of such cases by the roentgenogram alone, when visualization of each condition has been acquired by experience, since characteristic changes of both affections will often be present.

Prognosis.—In the acute stage, there is no affection in which the result is more favorably influenced by efficient measures, especially if instituted early, even though the infection is virulent. The prognosis depends largely on the virulence and distribution of the infection, which is indicated by the character of the effusion and the number of joints involved. The large number which terminate in malposition and ankylosis indicates that treatment in the average case is not efficient. The more severe the constitutional symptoms, as high temperature and other manifestations of sepsis, the greater is the prospect of organic destruction. If the effusion is serous, complete resolution usually may be expected; if seropurulent, destructive changes more often occur,

which may result in impairment of function by fibrous ankylosis or malposition. If purulent or suppurative, there is a still greater degree of destruction with frequent loss of function, or death may ensue as a result of sepsis. The salvage of the joint, in the subacute stage, depends on the extent of destruction in the intra-articular structures. In the stage of residual impairment, if appreciable motion is present, function may be restored to a large degree by mechanical and surgical measures. The degree of ankylosis depends upon the virulence of the infection and the efficiency of early treatment. When ankylosis is present, restoration of function may be accomplished by arthroplasty in selected cases.

Treatment.—A careful search should be made for foci of infection, and wherever possible, such foci should be eradicated, although the removal of the infected focus is rarely beneficial when the pathologic process has become well inaugurated. The eradication of such foci is usually contraindicated during the acute stage of infectious arthritis, because of the danger of instigating a virulent infection of the blood stream with secondary foci in other parts of the body. During the acute stage, supportive treatment is frequently necessary, such as intravenous injections of saline or solutions of glucose, and blood transfusion. Blood for transfusion should be carefully typed, and the method of typing the patient's blood against the individual donor is preferable to the selection of the donor corresponding to the patient's blood group. Recently success has also been reported by Young and others by the intravenous injection of a solution of mercurochrome or gentian violet, and amiodoxyl benzoate, as suggested by Young and Youmans, may be of value, especially in acute gonorrheal arthritis. Local heat or cold may be applied probably with more comfort than benefit to the patient. After the acute symptoms have subsided, all active foci, as tonsils, sinuses, and teeth, should be removed in order to prevent recurrence of the infection in other joints or other parts of the body. The constitutional treatment during convalescence is similar to that following any acute infectious process, and consists of such measures as tonics, nourishing food, rest, fresh air, and sunshine.

The local treatment is essentially surgical. In the early stages, there are several forms of local treatment which may be employed. However, such measures cannot be used unless the indications, contraindications and technic of administration are well understood. Aspiration should be employed in every case to determine the nature of the effusion and to relieve intra-articular pressure. The withdrawal of fluid from the joint and the injection of formalin in glycerin, as advo-

cated by Murphy, will be sufficient in serous or seropurulent effusions. Another method consists of copious irrigation of the joint with a sterile bland solution, as advocated by Cotton. This method, however, is not applicable to all joints on account of their mechanical construction. In purulent or suppurative effusions, efficient drainage is often indicated, the technic of which must obviously be adapted to each joint and each individual case. Rubber tubes, gauze or other material should not be used, except in extreme sepsis and should be inserted down to, but not within, the joint. Strips of gauze bandage impregnated with vaseline usually answer all purposes. During the World War, Willems devised a method of treatment which consists, first, in débridement and efficient drainage by incision, after which active motion is carried out for a few minutes at intervals of one hour. The range of motion is gradually increased, but not to such an extent as to induce pain or inflammatory reaction. No passive motion is attempted. This method, however, is impracticable, unless the patient can be under the constant supervision of the surgeon with the aid of an efficient corps of nurses. In young children, the method is impossible, in older children difficult, and in the average private home, out of the question. In gunshot wounds of joints, for which the measure was devised, the Willems' treatment has been found most effective. According to Willems, his treatment is also applicable to hematogenous infections, such as are encountered frequently in civil practice, but is only instituted in those cases which are observed at the onset or during the early stage of the infection. In hematogenous infections débridement is, of course, not necessary.

Orthopedic measures are indicated in all cases. The keynote of success is the prevention of deformity or malposition; otherwise, the affected joint or joints may be rendered useless with partial or total disability, though a fair range of motion may remain. Continuous traction by Buck's extension should be employed when feasible. If actual dislocation is present, reduction, after drainage, can often be accomplished, even in the acute stage, without excessive force, and can be maintained by suitable apparatus. If the joint is not retained in the most useful position, in addition to malposition and deformity, atrophy or osteoporosis results. Each joint is an individual equation and must be maintained in that position in which function will be most useful from the mechanical standpoint of the part involved. Should malposition exist when the patient is first observed, gradual correction must be obtained by special apparatus constructed to meet the requirements of the particular joint involved.

In the subacute stage, the process is one of resolution and organiza-

tion; therefore, injections or other treatment to the interior of the joints can be of no value, and, in fact, are positively contraindicated. However, in many instances, function may yet be restored by rational procedures. If malposition exists, correction must be gradually effected by apparatus. A practical range of active and passive motion when present should be encouraged by well-directed exercises and physiotherapy, but if the process has been so extensive that restoration of function cannot be secured, splints or apparatus are employed to maintain the part in the most useful position until the process has entirely subsided. In early childhood when cooperation is impossible, efficient fixation should be continued throughout. The danger of permanent deformity is ever present until the patient is able to maintain the joint in the most useful position by his own volition.

Forcible passive motion, so-called brisement forcé, either with or without anesthesia, should rarely, if ever, be employed. However, this practice is rather common and may produce serious damage. Adhesions are more resistant than bony structures and, therefore, gross fractures, crushing of atrophic extremities of the bones and violent reaction within the joints, followed by further organization and stronger adhesions, may result. There is no counterpart to brisement forcé in the treatment of inflammatory conditions elsewhere in the body; for example, no physician would dare force feeding in the subacute stage of an acute enteritis. Physiotherapy, continuously and carefully administered by an expert, who appreciates that the restoration of function can be accomplished only by gently applied movements, and never by sudden and violent force, is a valuable adjuvant.

In the third, or residual stage, as in all pyogenic infections, a potential danger of infection remains indefinitely and may be relighted by surgical interference, or other forms of treatment. However, when the infection is confined to the joint, and if sufficient time is given for the disappearance of all acute symptoms, the possibilities of such complications are rare. In adults, when ankylosis has occurred, restoration of function may often be accomplished by arthroplasty, though the results are largely dependent upon the joint involved. Deformity and malposition may often be gradually corrected by special apparatus devised to meet the mechanical requirements of each joint. Function may also be increased when there is a practical degree of motion by certain corrective exercises. Operations which are carried out for the correction of deformity and restoration of function consist of tenotomies, fasciotomies, forceful corrections, osteotomies, and excision of scar tissue in the joint. From the onset, and throughout the entire course of acute

infectious arthritis, the prevention and correction of malposition and deformity cannot be over-emphasized.

ACUTE INFECTIOUS ARTHRITIS OF THE FOOT

Acute infectious arthritis of the phalangeal joints is comparatively rare. Infection of the metatarsophalangeal joint is frequently observed, and polyarthritic invasion often begins in one of these joints. When acute pyogenic infection occurs in one of the metatarsophalangeal joints, pain and tenderness may persist to such an extent as to prevent weight-bearing for an indefinite period. When the tarsal joints are invaded, osteomyelitis of the tarsal bones, with extensive osseous necrosis, may complicate and involve the entire foot, terminating in a conglomerate fusion of the ankle and all of the tarsal joints. Varus or valgus not infrequently occurs. In infections of the joints of the tarsus or metatarsus, invasion of the periarticular structure and tenosynovitis of the dorsal tendons are frequent complications. This results in dorsal contractures of the toes or clawtoes, with prominence of the heads of the metatarsal bones, which may induce pain on weight-bearing.

Treatment.—As the process in the tarsus is usually associated with osteomyelitis, drainage is often indicated, but care should be taken to avoid the tendons when operating; otherwise, an extensive tenosynovitis may ensue. Care must also be taken to prevent dorsal extension of the toes by repeated flexing, or by the use of digitated metal splints or sole plates. In affections of mild degree, correction may at times be obtained by physiotherapy, massage and digitated splints to be worn at night. As soon as weight-bearing is possible a rigid arch support should be placed in the shoe; if there is a tendency to clawtoes, an elevation should be placed on the arch support posteriorly to the heads of the metatarsal bones to induce plantar flexion when weight is borne. In those in whom the soles of the feet remain tender for an indefinite period, the arch support may be made of saddler's felt to be used until more efficient apparatus can be endured. If the contractures are severe and of long standing, operative removal of the heads of the metatarsal bones is necessary, the technic of which is described in the chapter on Static Deformities.

The degree of function depends upon the amount of resiliency reestablished in the foot. In the residual stage correction of varus and valgus, when present, can usually be accomplished by forcible manipulation. Operations of capsulotomy, cutting the capsule, with tenoplasty and excision of all scar tissue are indicated in children, and may be employed as a conservative measure in adults, but the possi-

bility of recurrence in severe cases is great, and when extensive cicatrization is present, only radical measures should be considered. A wedge-shaped tarsectomy may be required to restore the normal arch and contour of the foot. If motion remains in some of the joints, the deformity should be corrected by osteotomy through the nonarticular portions of several bones. Great care must be taken that the osseous surfaces are maintained in close approximation until there is solid osseous fusion; otherwise, fibrous union may occur which may be painful on weight-bearing. Weight-bearing should not be permitted until all acute tenderness has disappeared. An arch support should be worn until fusion, demonstrated by the roentgenogram, precludes all possibility of recurrence of the deformity.

ACUTE INFECTIOUS ARTHRITIS OF THE ANKLE

When the ankle is involved by a pyogenic infection, fluctuation is often elicited with difficulty, as extensive swelling of the periarticular tissues completely obliterates the malleoli and other osseous prominences about the joint. The foot falls by gravity into equinus and the tendo achillis and posterior capsule of the ankle become rapidly contracted; unless this position is prevented fixed deformity will result.

Treatment.—After any and all forms of treatment, occurrence of the equinus position must be prevented, and this may be accomplished by a simple ankle splint which extends from the foot to just below the knee, holding the foot at right angle to the leg. Aspiration should be made on the anterolateral aspect of the ankle joint about 1 inch above the level of the external malleolus and about $\frac{1}{2}$ inch internal thereto. At this point tendons, nerves, and vessels will not be injured.

Irrigation of the joint may, at times, be beneficial, but is usually not practicable on account of the mechanical structure of the ankle joint. Unless the process is mild, drainage of the ankle joint may be required. There are five locations for incision and drainage: anterolateral, posterolateral, anteromedial, posteromedial, and anterior median. An anterolateral incision of 2 or 3 inches in length is made over the ankle joint about $\frac{1}{2}$ to 1 inch internal to the external malleolus, which can be carried through the soft structures and the capsule of the ankle joint. A small tube or vaseline gauze pack may be inserted down to, but not into, the joint. This will usually suffice, but the posterolateral route has been proved experimentally by David to be safer and more efficient. For this incision the foot should be dorsiflexed, which tends to obliterate the anterior compartment and correspondingly to increase the posterior compartment; dorsiflexion also represents the best func-

tional position for fixation. Every drop of the fluid may be evacuated, provided the foot is placed in the dorsiflexed position. The incision is made on the posterolateral aspect of the ankle joint $1\frac{1}{2}$ cm. lateral to the tendo achillis, beginning 5 cm. above the external malleolus and

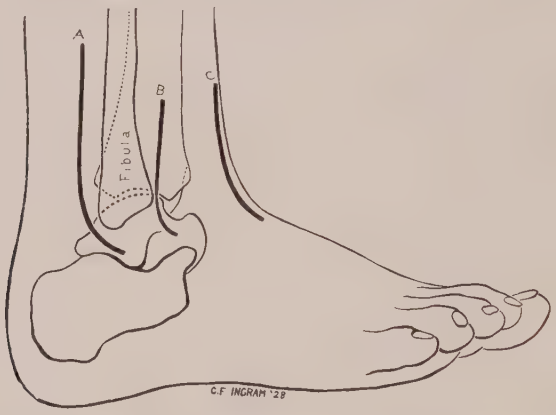


Fig. 68.—Location of incisions for drainage of ankle joint: *a*, Posterolateral; *b*, anterolateral; *c*, anterior median.

extending down to the os calcis, following the superior border for $1\frac{1}{2}$ cm. The external saphenous nerve and vein are encountered and are retracted posteriorly. A thick pad of fat is seen hugging the posterior ligament. This may be pressed down against the entrance to

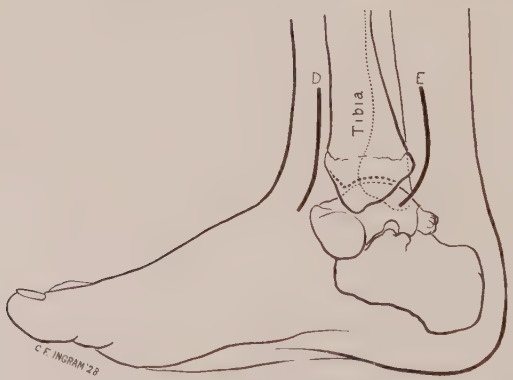


Fig. 69.—Location of incisions for drainage of ankle joint: *d*, Anteromedial; *e*, posteromedial.

the subastragalar joint for protection. The ankle joint is entered above the shining cordlike posterior fasciculus of the external lateral ligament. Incidentally, it may be remarked that this incision affords an excellent approach for drainage of the subastragalar joint as well.

The anteromedial incision may be made overlying the head and neck of the astragalus. Care must be taken not to injure the extensor tendons and the anterior tibial artery.

When the infection is severe, posterior medial drainage may be secured through an incision 3 or 4 inches in length made internal to and parallel with the tendo achillis. The tendon of the flexor longus pollicis will be observed to traverse the posterior capsule of the joint from above downward and inward, and must be retracted upward. A small tube should be placed down to the joint or a vaseline gauze pack inserted. The anterior median incision, made in the midline, anteriorly, may be employed to drain the anterior compartment of the joint.

The Willems treatment of active motion is particularly applicable to the ankle, but especial care should be taken to avoid contraction of the tendo achillis, which may occur if cooperation of the patient is not

Fig. 70.—Detail of posterolateral incision into the ankle joint. The peroneal tendons are retracted forward.

secured. If the Willems treatment is not employed, active and passive motion may be instituted in the ankle as early as possible after the subsidence of acute symptoms and is greatly facilitated by special apparatus for this purpose, as described in the chapter on Apparatus. If the process is first observed in the subacute stage, deformity can be corrected by special apparatus which gradually flexes the foot dorsally, or correction may be accomplished in the same manner in the residual stage. However, in those with organized contractions, with the foot fixed in equinus, surgical measures are instituted which require severance of the tendo achillis and often the posterior capsule of the ankle joint, after which the foot is maintained by apparatus at right angle to the leg. Arthroplasty for ankylosis of the ankle joint is rarely indicated unless ankylosis is also present in the tarsal joints.

ACUTE INFECTIOUS ARTHRITIS OF THE KNEE

Acute infectious arthritis of the knee is instituted by a sudden onset and all signs of inflammation, such as pain, heat, redness, swelling, and impairment of function, are exaggerated. The joint is held in flexion of about 150 degrees. On inspection and palpation, an increase of fluid will be found within the joint, which may vary in amount from slight fluctuation to complete distention with obliteration of anatomical contour. The process is apparently more active in the knee joint at the point of greatest bony contact, evidenced by erosion, which begins more frequently on the articular surface of the internal condyle of the femur. Unless arrested, there is a gradual destruction of the superficial surfaces of both condyles of the femur and the tuberosities of the tibia.

Fig. 71.—Acute infectious arthritis of knee, anteroposterior view.

Fig. 72.—Same as Fig. 71, lateral view, showing subluxation of tibia.

Contractions of the hamstring tendons and posterior structures, nature's effort to assume the neutral position, often cause subluxation of the tibia, with external rotation and genu valgum, a deformity characteristic of a destructive process in the knee joint. The diagnosis is apparent from the symptoms and may be easily confirmed by aspiration, which is made on the anterolateral and anteromedial aspect on a line with the upper border of the patella.

Treatment.—*Acute Stage.*—In the acute stage, and during the entire clinical course, deformity can and always should be prevented. Buck's

extension allays pain, corrects and prevents malposition, and is a most valuable measure until all acute symptoms subside. Also simple gutter splints may be employed to maintain extension, which is the most serviceable position of the knee. There are three systematic methods of treatment that are highly recommended: (1) Murphy technic, (2) the method of Cotton, and (3) Willems' method.

Murphy Technic.—The Murphy technic consists of aspiration of the joint, withdrawing from 10 to 20 cc. of fluid, after which an equal amount of 2 per cent formalin in glycerin is injected through the same needle without removal. The solution must be prepared twenty-four hours before injection. If the symptoms are not abating by the end of twenty-four or forty-eight hours, a second treatment is given; and after another period of twenty-four or forty-eight hours a third injection may be given, but rarely more than two treatments are necessary. Repeated aspiration is required should the joint become overdistended during the course of the treatment.

Cotton Technic.—The method of Cotton consists of copious irrigation with normal salt solution or 1 : 15,000 bichloride of mercury. Irrigation is accomplished by the introduction of a small trocar and cannula on either side of the joint, one of which may be attached by rubber tubing to a 1-gallon douche can. From 3 to 5 gallons of solution should be used. The treatment may be given every second day until constitutional and local symptoms have subsided, although rarely more than one treatment is required.

Willems' Technic.—The Willems treatment was devised for gunshot wounds; however, the originator of the method also claims excellent results in hematogenous infections. The technic is as follows: All damaged tissues surrounding the wound external to the opening in the synovial membrane are carefully removed and hemorrhage controlled. The instruments are then changed, or resterilized before entering the joint. All contused edges of the synovial membrane are removed. The joint is kept open as short a time as possible in order to prevent drying of the synovial membrane, since a dry membrane seems to predispose to ankylosis. All foreign bodies are removed together with the detached bone fragments. If the foreign body is buried in the bone, all devitalized bone surrounding the tract is chiselled away. If possible, all the procedures should be performed without gloved hands being introduced into the joint, or without touching any contacting part of the instruments to be introduced. After careful examination of the joint, decision is made as to whether or not sufficient undamaged articular cartilage remains to make possible the hope of subsequent restoration of function

by immediate postoperative mobilizing movements. A culture is taken of the contents of the joint to determine subsequently the presence or absence of hemolytic streptococci; which, if present, make speedy drainage of the joint necessary. All bone edges are smoothed off, after which the joint is thoroughly washed out with any nonirritating bland solution, such as Dakin's solution or normal salt solution, followed by flushing with pure ether. The edges of the capsular opening are then completely closed with a plain continuous catgut suture either through-and-through, or, as some prefer, so passed that no suture appears inside the joint. In neglected cases, or those in whom there is a virulent purulent infection, especially by hemolytic streptococci, the joint should not be closed. However, Willems puts special emphasis on closure of the capsule when possible. The external open wound may be loosely packed with gauze wet in Dakin's solution, or Carrel's tubes may be placed in position in the wound for subsequent treatments with Dakin's solution. A bandage is loosely passed about the dressing so as not to impede subsequent movements. No splint should be applied.

Active motion is instituted as early as possible, and gradually increased in amplitude until normal function is obtained. These movements are carried out every hour, or every two hours, day and night. This requires constant surveillance for the ertire twenty-four hours by a corps of efficient nurses who are well trained in every detail of this treatment. Weight-bearing is encouraged within a very few days and increased as rapidly as possible. Pain is usually relieved by energetic exercise which forces the accumulated pus out of the joint. However, if pain persists, with fever and loss of power, there is retention of pus, which must be again evacuated.

Drainage.—Incision and drainage may be required when there is virulent infection, manifested by symptoms of sepsis and purulent exudate. Drainage is best secured by lateral incisions of about 3 or 4 inches in length on both sides of the patella. The capsule may be stitched to the skin to prevent invasion of the periarticular tissues and cellulitis. After incision, copious douching of the joint with a bland antiseptic fluid followed by ether may be employed. Gauze impregnated with vaselin is then packed down to, but not within, the joint. Rarely, it is necessary to drain the posterior compartments of the knee joint.

The posterior compartment of the knee joint is practically divided by a mesial septum into internal-posterior and external-posterior compartments. Posterolateral incisions described by Henderson may be necessary on both sides, but both incisions are small and practically no

dissection is needed. The knee is flexed and an incision made on the outer side, well posteriorly, but anterior to the head of the fibula, thus carefully avoiding the external popliteal nerve which passes over the posterior aspect of the head of the fibula. If exploration of the medial compartment is necessary, a second incision must be made on the inner side, anterior to the relaxed tendons of the semimembranosus, semitendinosus, sartorius, and gracilis muscles.

If more extensive drainage is required, the incision described by Brackett and Osgood and also by Putti may be employed. A median

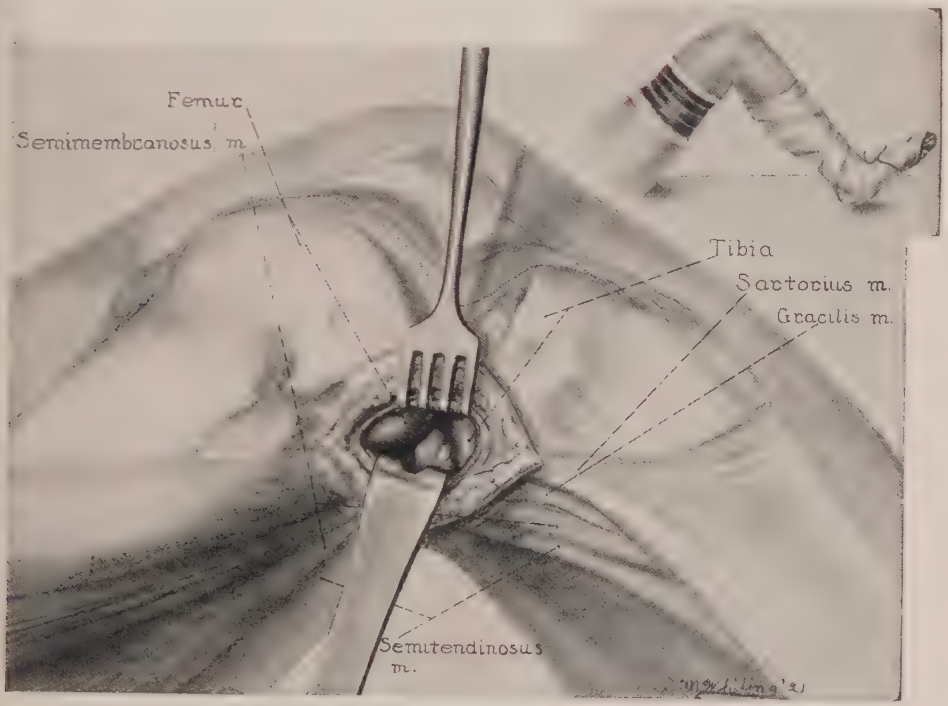


Fig. 73.—Incision for drainage of posteromedial compartment of the knee joint. (Henderson, Surg., Gynec. and Obst., 33, 698.)

incision is made in the popliteal space exposing the tibial and peroneal nerves. The posterior capsule of the knee joint is exposed by blunt dissection, retracting the nerves and biceps laterally and the popliteal vessels and internal hamstring tendons medially. The external head of the gastrocnemius and the popliteus muscles are now defined on the outer side and the internal head of the gastrocnemius on the inner side of the incision. A transverse incision is now made into the capsule, first over both internal and external condyles of the femur, and

then completing the incision across the joint. The split patellar and transverse incisions with exposure of the entire joint, with and without extreme flexion, are not only mutilating, but also unnecessary in pyogenic infections, and are mentioned only for the purpose of condemnation.

Fig. 74.—Acute infectious arthritis of knee with flexion deformity.

Subacute Stage.—In the subacute stage, when deformity is present, correction should be gradually secured, but never by sudden force. If slight, or nonresistant, Buck's extension may be sufficient, but the traction must be begun and continued in the angle of deformity, adjust-

Fig. 75.—Correction of flexion deformity of knee secured by gradual tightening of turnbuckles. Note attachment for upward pressure on tibia to prevent subluxation.

ing the pull as reduction is accomplished. After extension has been secured, a posterior splint is applied until the active symptoms subside. Deformity of the knee, when resistant, may be gradually corrected by the use of a special appliance employed by the author, described in the chapter on Apparatus.

The roentgenogram will demonstrate the degree of destruction in

the joint; if this has been so extensive that the joint is beyond restoration, immobilization in extension is continued until ankylosis ensues. However, if the roentgenogram and clinical manifestations show that there remains a sufficient area of articular surface to make possible a practical range of motion, every attempt should be made to reestablish function by active and passive motion and intelligently applied physiotherapy. A practical range of motion with excellent function may be acquired in many cases who are apparently hopeless. The cultivation of function of the knee which is described in detail in the chapter of Ankylosis, may be routinely employed during convalescence from many affections.

Residual Stage.—In the residual stage, deformities should be corrected by reconstructive measures designed to meet the requirements

Fig. 76.—Method of instituting passive motion in knee joint by modified Thomas knee splint and overhead sling.

of the individual case, and under no circumstances should gross deformity be permitted to exist in the knee joint. If there is a fair range of motion present in the flexed position, extension may often be accomplished by the corrective knee apparatus; otherwise, operative measures are indicated and correction is possible in all by either osteotomy or by resection of bone. Sudden extension maintained under tension should not be applied, as there is great danger of serious interference with circulation and injury to the nerves, which may cause either permanent paralysis or a persistent traumatic neuritis. If correction cannot successfully be made at operation, without undue tension on the soft

structures, partial correction should be secured, and after a short period, full correction can then be obtained without danger by manual force or corrective apparatus. When ankylosis ensues, the possibility of restoration of function by arthroplasty is excellent in selected cases.

ACUTE INFECTIOUS ARTHRITIS OF THE HIP

In adults, the process begins within the hip joint, while in children, the infection often begins in the epiphysis and is frequently called epiphysitis. As the capsule of the joint encloses a greater portion of the neck of the femur, osteomyelitis is usually a complication. Distention of the joint capsule often induces complete dislocation in the early

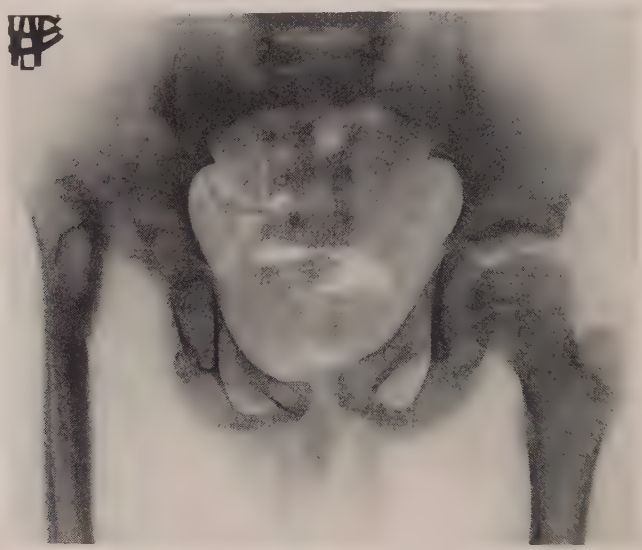


Fig. 77.—Epiphysitis, osteomyelitis of neck of femur, and dislocation by distention of joint capsule.

stage. Dislocation may also be a later complication after invasion and disintegration of the superior wall of the acetabulum or the head and neck of the femur. Osteomyelitis in the neck of the femur may extend across the joint into the cavernous bone of the ilium, inducing an extensive osteomyelitis of the ilium. The hip is often involved in a polyarticular infection. Bilateral infection is also more frequent in the hip than in any other joint, and is often associated with acute infectious spondylitis. This is possibly due to the fact that as the abdominal aorta divides a very short distance above the level of the hip joint, circulation is more direct.

Symptoms.—As the joint is deep seated, local manifestations of an acute inflammatory process are not apparent as early as in the more superficial joints. Swelling and fluctuation are often not detected for several days, while redness of the skin and local heat may not be present. There is tenderness on palpation over the joint which can often be accentuated by pressure over the trochanter, as osteomyelitis of the neck of the femur is often associated. As in all destructive processes involving this joint, in the early stage the hip is held in flexion often associated with abduction and external rotation. Active motion is absent or extremely limited, while passive motion is partially but not entirely restricted. Rarely, especially in young children, passive motion may be comparatively free. Early dislocation from distention of the

Fig. 78.—Acute infectious arthritis of both hips in residual stage with dislocation

capsule is usually first detected by the roentgenogram as the flexed position and swelling may obscure anatomical landmarks. The subacute stage is prolonged when there is extensive invasion or bone destruction. Draining sinuses from retained sequestra are more frequently present on account of the associated osteomyelitis. In the residual stage, after osseous destruction occurs, severe, fixed and grotesque deformities, such as extreme abduction with external rotation, may be observed, although flexion with adduction and internal rotation is the more common. The hip may be completely ankylosed in malposition or there may be a functional range of motion.

Diagnosis.—The diagnosis is evident from the local and constitutional symptoms; the roentgenogram, as in acute osteomyelitis, shows

no change in the bone for the first few weeks. Distention of the capsule may be detected. Aspiration for the purpose of diagnosis is more difficult in the hip joint than in any other location, and consequently, attempts must often be made in several directions before success is achieved. A needle of sufficient size and length should be inserted just anterior to the greater trochanter, upward and inward, parallel to the neck of the femur, but very closely thereto. If aspiration from this point is not successful, the needle may be inserted at a point just above the trochanter with an upward inclination of about 30 degrees, or, finally, from the posterior aspect.

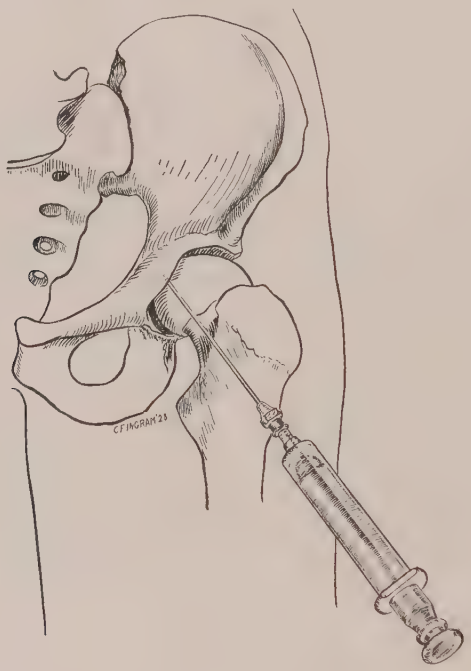


Fig. 79.—Method of aspiration of hip joint. Note direction of needle, anterior to and parallel with the neck of the femur.

Differentiation from an acute psoas abscess may be difficult. In psoas abscess, tenderness and a mass may be detected on deep palpation above Poupart's ligament, and motion is chiefly limited in extension; whereas, in acute infectious arthritis, the hip is virtually restricted in all directions. Differentiation from tuberculosis may also be necessary in the subacute and residual stages. In low-grade inflammatory processes of the hip, there may be a massive induration above Poupart's ligament, but the condition can always be differentiated from acute infectious arthritis by the history.

Prognosis.—Great destruction with permanent disability is observed more frequently in the hip than in other joints. Osseous destruction is often more extensive due to the invasion of the bony structures on both sides of the joint. Unless early and efficient measures are introduced permanent disability may usually be expected.

Treatment.—Buck's extension alone may be sufficient in very mild infections and should be instituted at once to prevent deformity. Early and efficient drainage is usually imperative, not only for the evacuation of pus and the relief of intra-articular pressure, but also to limit osteomyelitis and prevent dislocation. In the acute stage, dislocation when present should be reduced as soon as discovered and can usually be accomplished at the same time drainage is made. Drainage may be secured from the anterior, posterior or lateral aspects, but is more effectively accomplished posteriorly, as described by Ober. An incision is made in line with the neck of the femur, beginning at the posterolateral aspect of the femur and extending obliquely upward and backward toward the sacrococcygeal articulation. The capsule is split longitudinally throughout its entire length, and, if necessary, transverse incisions may also be made. In cases of septic arthritis two cigaret drains are sutured to the outside of the capsule, and being posterior and dependent, they drag the capsule into a funnel shape, giving efficient drainage.

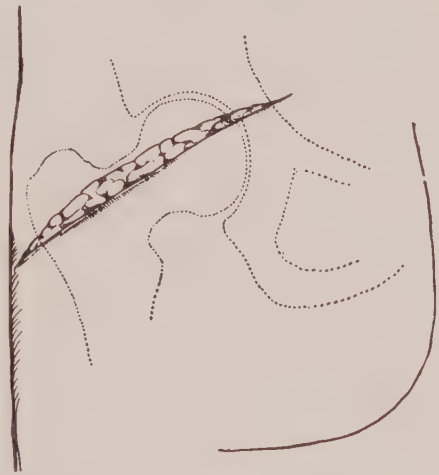


Fig. 80.—Ober incision for drainage of hip.

In the subacute stage, deformity, when present, may be corrected by traction. The force must be applied in the angle of deformity and adjusted as the deformity is reduced. The patient should be maintained in the recumbent position on a nonyielding surface; otherwise, flexion of the hip will persist and may become permanently fixed. As it is often impossible by the usual methods of extension to make a full correction of rotation and other malpositions at the same time, a special apparatus was devised by the author by which all movements of the hip could be gradually induced, such as rotation, abduction, adduction, flexion, and hyperextension. Dislocation can be reduced by mild

manual force if the head of the bone is on a level with the acetabulum, but if above the acetabulum, even mild force is contraindicated as crushing or fracture of the bone will result. When ankylosis is impending, the limb is placed in apparatus which maintains the most serviceable position, until fusion is solid and there is no tendency to recurrence of deformity. This position is 20 degrees abduction, complete extension, and neutral rotation. If a sufficient area of articular surface remains, a practical range of motion may be restored by active and passive exercises, which is greatly facilitated by overhead sling and pulley.

In the residual stage, malposition can at times be reduced by apparatus, though frequently surgical measures appropriate to the requirements of the individual case are necessary. If there is a considerable range of motion with the joint in malposition, correction may often be secured by extra-articular procedure; for example, when flexion with abduction and external rotation persists, the author's operation of transference of the crest of the ilium, described in the chapter on Poliomyelitis, will restore anatomical alignment and function will be materially increased by the normal activity of the part. Subtrochanteric osteotomy is seldom required, as intra-articular correction can often be secured. When ankylosis ensues, arthroplasty is indicated and in many instances will restore function.

Acute Infectious Spondylitis

Acute infectious spondylitis, though occupying comparatively little space in literature, occurs more frequently than is generally known, and is considered of sufficient importance by the author to warrant a separate description. The etiology, onset, clinical course, and blood manifestations are identical with acute infectious arthritis elsewhere in the body.

Pathology.—Any region of the spine may be affected, and the process may involve only a single intervertebral disk and the adjacent vertebrae, or may be diffused throughout a considerable portion of the spine. In mild cases, the infection causes only a moderate amount of bone destruction, which is quickly and spontaneously restored to normal by the reparative forces of the patient. The body of the vertebra becomes eroded or compressed, and eventually, osseous proliferation is apparent within and around the affected area. Bone is deposited in the fascia and ligaments surrounding the intervertebral disks, and connects the contiguous segments of the spine. When the infection is diffused throughout several vertebrae, or a large segment of the spine, there are extensive changes in the bodies of the vertebrae with proliferation and coalescence of the bodies. In virulent infections, an extensive

osteomyelitis of the cancellous bone of the bodies of the vertebrae may occur with suppuration, sequestration, abscess formation and sinuses which drain indefinitely.

Symptoms.—Local and referred pain are constant symptoms. The pain referred to the peripheral distribution of the spinal nerves is caused by irritation of these nerves at the points of exit from the vertebral column. There is spasm of the muscle surrounding the affected area and rigidity of the spine. When the dorsal spine is involved, pain may be referred to the abdomen. If the lumbar spine is affected, the psoas muscle often becomes irritated, causing a well known entity, psoas contracture, which is evidenced by the hip becoming flexed, with inability to extend actively or passively, though other movements of the joint are comparatively free. Psoas contracture may be unilateral or bilateral. The process may begin with a chill and sudden rise of temperature, the curve of which is a typically septic one, being elevated in the afternoon with a correspondingly rapid pulse, and receding in the morning to about normal. When osteomyelitis is associated, the symptoms of sepsis are pronounced with extreme emaciation and bodily weakness. Abscess, which usually signifies an existing osteomyelitis, may be a complication. As the general symptoms subside, tenderness and muscular rigidity decrease, but deformity, as a rounded kyphos, may develop. The deformity may be progressive, but rarely develops to an exaggerated degree, as the vertebral column is reinforced rapidly by bone production.

Diagnosis.—The diagnosis in the acute stage may be apparent from the high temperature and other evidence of pyogenic infection, associated with local muscular spasm or rigidity, but is frequently overlooked as the examination of the spine is not a routine practice. When pain is referred to the abdomen in acute infectious spondylitis or other lesions of the dorsal spine, the condition may be mistaken for an acute inflammatory lesion of the abdomen, as appendicitis. In the subacute stage confusion with tuberculosis is too frequent. The differentiation should be made from the history alone, but if this is not possible, the roentgenogram will be diagnostic. In tuberculosis the symptoms exist for a much longer period before osseous destruction is apparent, and when evident, there is atrophy and destruction without proliferation. In the residual stage of infectious spondylitis, the deformity is not often so great as in tuberculosis, and is rarely progressive. Fractures of the spine may also be differentiated by the history and roentgenogram. An acute infection of the hip joint is often mistaken for psoas abscess, but may be differentiated by a careful examination of the

spine and hip. In psoas contracture, associated with acute spondylitis, the spine is limited in all directions, but the hip is free, except in extension and possibly abduction, when tension is made on the psoas muscle; in hip joint disease, there is marked limitation of motion of the hip in all directions, while motion of the spine is not restricted. There are no roentgenological manifestations for several weeks; later there is a characteristic mottling of the bodies of the vertebrae with a decrease in the width of the intervertebral space between the affected vertebrae, until only a line of cleavage may be visible. New bone production or

Fig. 81.—Subacute infectious spondylitis, with narrowing of intervertebral space between fourth and fifth lumbar vertebrae.

Fig. 82.—Same as Fig. 81. Lateral view.

involucrum becomes apparent about the vertebrae as in osteomyelitis of other bones, and when a portion of the vertebra is separated as a sequestra it may be seen in marked contrast to the surrounding atrophic bone tissue. After healing has taken place there exists a massive fusion of the vertebral bodies.

Prognosis.—When the process is confined to a small area, complete and permanent recovery may be expected, in a large percentage, without deformity or impairment of function if efficient measures are instituted early. In virulent infections, however, especially if there is an extensive osteomyelitis, death may ensue before an accurate diag-

nosis is made. When only a few vertebrae are ankylosed, function will be restored by a compensatory increase of motion in the spine above and below the area involved.

Treatment.—If pus can be located by aspiration about the spine, incision and drainage are indicated. Psoas abscess, when present, may be drained by an incision 1½ to 2 inches in length, just below Poupart's ligament, with blunt dissection beneath the ligament. The abscess may also be drained through the lumbar muscle. The spine should be held firmly in moderate hyperextension on a Bradford frame. This position separates the vertebrae and prevents deformity. Extension may give great relief and should be applied to both lower extremities when the lower portion of the spine is involved; to the head when the upper portion is involved; or, to the head and extremities when the midregion is involved. Body casts, braces or ambulatory appliances should not be employed until the acute symptoms have subsided. A plaster jacket or spinal brace commensurate with the region affected is then applied and walking permitted. Fixation apparatus should be continued for six months to a year, or until the spine has sufficient strength to sustain the superincumbent weight. When the apparatus is discarded, there should be constant supervision and periodical examinations by the physician for another year. If there is ankylosis, compensatory motion can be developed by properly directed exercises. Should pain or other evidence of inflammation occur, the exercises should be discontinued for at least one month. Deformity and postural defects of the spine in the residual stage require corrective jackets and complicated apparatus suited to the individual case.

Typhoid Spine

A type of infectious spondylitis due to inflammatory changes in the ligaments and bones of the spine, occurring during an attack of or convalescence from typhoid fever, was first described by Gibney. The lumbar region is most frequently affected, and paroxysmal attacks of intense pain with muscular spasm are of common occurrence during the acute stage. The pain is of such severity that the patient often refuses to be moved from the recumbent position, and dreads the slightest jar or shock, as such slight movements will precipitate spasmodic contraction of the muscles with excruciating pain. A kyphos develops gradually, and the roentgenogram shows rarefaction of the vertebrae and proliferative changes in the intervertebral ligaments, which eventually result in the formation of osteophytes and produce ankylosis. The Widal test is positive.

The treatment consists in immobilization of the spine on a Bradford frame or in a plaster cast during the acute stage, which should be followed by a brace commensurate with the affected region until all symptoms have subsided, which usually requires from six months to one year. Acute arthritis of the joints, other than the spine, may also follow typhoid fever, the symptoms being similar in all respects to arthritis due to other organisms, the only points of differentiation being the isolation of the typhoid organism from the joint fluid and the positive Widal reaction.

Acute Infectious Arthritis of the Shoulder

The process in the shoulder rarely induces extensive destruction of bone, and ankylosis is infrequent. This is due to the normally loose construction of the joint and the separation of the head of the humerus from the glenoid cavity of the scapula. Increased articular pressure by fluid and gravity acting on the pendulous upper extremity further increases the separation between the joint surfaces. The erroneous diagnosis of dislocation is often made when the roentgenogram demonstrates this wide separation of articular surfaces. Conservative measures are often sufficient, unless the process is virulent. The arm should be maintained in abduction of about 45 degrees until the process subsides. No traction should be employed, but fixation is indicated and may be accomplished by a splint or simple axillary pad. Drainage, when necessary, may be secured by the anterior, lateral or posterior routes, as the joint is easily accessible on all sides. As aspiration of the shoulder is easily accomplished, the method of irrigating the joint, described by Cotton, may be effectively employed.

Acute Infectious Arthritis of the Elbow

As the articular surfaces of the elbow are normally so closely approximated, superficial erosion of the cartilage frequently results in ankylosis. Also, the attachment of the capsule renders the lower extremity of the humerus vulnerable to direct infection, and osteomyelitis with osseous destruction is a frequent complication. As the elbow is such a superficial joint, the local signs and symptoms are apparent at the onset. If the process is mild, injection with formalin and glycerin, or copious douching of the joint may be employed. In most instances, incision and drainage are required and can be accomplished by a long posterior incision just external to the olecranon process, exposing the capitellum and head of the radius, after which the joint is douched with salt solution, or, with 1 : 15,000 bichloride of mercury, followed by ether. A vaselin pack is inserted down to, but not within, the joint. Occa-

sionally, through-and-through drainage may be required and can be accomplished by additional incisions, but care must be taken to avoid injury to nerves and vessels. The joint is adaptable to the Willems treatment of active motion if instituted at the onset. When ankylosis is impending, regardless of the treatment, the joint is placed in the most serviceable position, which is an angle of less than 90 degrees between the arm and forearm. Should ankylosis ensue, function should be restored after the subsidence of acute symptoms by arthroplasty.

Acute Infectious Arthritis of the Wrist

When the wrist joint is invaded by pyogenic organisms the process is extensive, as the infection invariably extends between all of the carpal joints and usually induces osteomyelitis of the small carpal bones. The same principles of treatment are applied as in other joints. Drainage may be accomplished by two lateral incisions or a posterior incision between the extensors of the thumb and the extensor digitorum communis, care being taken not to enter the sheaths of the tendons. Vaselin gauze packs are placed down to the joint. The wrist should be held in dorsal extension by a simple cock-up splint and hot wet packs should be applied continuously. The Willems treatment may also be employed, but cooperation of the patient is difficult to obtain. The fingers should be frequently moved by active and passive motion if possible and the flexed position should be encouraged, as this obviously facilitates functional use after the subsidence of the acute symptoms. Tenosynovitis is often a complication, and may cause permanent disability, or may require operative measures for pyogenic infection of the hand. Infections of the metacarpophalangeal and phalangeal joints rarely require drainage, as they usually occur in the course of polyarthritis and do not progress to suppuration.

If first observed in the residual stage, with the fingers in extension and the wrist flexed or subluxated, extension of the wrist may often be accomplished gradually by means of a malleable splint, or, rarely, by forcible correction, after which a cock-up splint is applied. The fingers may be gradually flexed by a reversed banjo splint. Physiotherapy should then be instituted and continued until the tip of each finger can approximate the tip of the thumb, when active use with well directed exercises may effect restoration of normal function.

BIBLIOGRAPHY

Brackett, E. G., and Osgood, R. B.: The Popliteal Incision for the Removal of Joint Mice in the Posterior Capsule of the Knee Joint, A Report of Cases, Boston Med. and Surg. Jour., 165 : 975, 1911.

Cotton, F. J.: Disinfection of Septic Joints, Jour. Bone and Joint Surg., 8:395, 1926.

David, S. D.: Experimental Incision on the Cadaver for Drainage of the Ankle Joint, Jour. Bone and Joint Surg., 5:480, 1923.

Gibney, Virgil P.: The Typhoid Spine, New York Med. Jour., 1:596, 1889.

Henderson, M. S.: Posterolateral Incision for the Removal of Loose Bodies from the Posterior Compartment of the Knee Joint, Surg., Gynec., and Obst., 33:698, 1921.

Murphy, J. B.: Luxation and Osteo-arthritis, Clinics of John B. Murphy, 4:1224, No. 6, December, 1915.

Ober, F. R.: Posterior Arthrotomy of the Hip Joint, Jour. Amer. Med. Assoc., 83:1500, 1924.

Putti, V.: La Capsulotomia Poplitea Mella Cura Della Retrazuoni Fles Sorie del Ginocchio, Chir. Org., Mov. 5:1, 1921; idem. Jour. Orthop. Surg., 2:530, 1920.

Willems, C.: Immediate Active Mobilization in the Treatment of Gunshot Wounds of the Joints, Med. Rec., 95: 953, 1919.

Young, Hugh H.: The Sterilization of Local and General Infections, Jour. Amer. Med. Assoc., 87:1366, 1926.

CHAPTER V

LOW-GRADE AFFECTIONS OF JOINTS

The low-grade joint affections comprise a large group with varying etiologic and pathologic features, but present such common clinical characteristics as to warrant their classification together. The onset is usually gradual and often insidious and the clinical course always slow and indefinite. The etiologic factor is well known in some, while in others it has not yet been proved; therefore, the term *affection* is more applicable than *infection*. The affections of this class are: (1) Low-grade infectious arthritis; (2) progressive polyarticular arthritis; (3) hypertrophic arthritis; (4) gout; (5) syphilis; (6) trophic affections or arthropathies; (7) osteochondritis (epiphysitis); (8) endocrine disturbances; (9) hemophilia; (10) neoplasms; (11) tuberculosis; (12) traumatic arthritis.

The etiology is specific in most instances, but the various members of the group have many causes in common. Certain of the affections in this group, as tuberculosis and syphilis, closely resemble each other clinically and require careful differentiation, whereas others can not be easily confused. The great importance of focal infection as an etiologic factor in joint disease can not be too strongly emphasized. A focus of infection is any circumscribed area of tissue which is inoculated by pathogenic bacteria. Infectious foci may be primary when the infection is carried directly from the focus to the joint, or secondary when the bacteria are first deposited in an adjacent or distant structure as a result of hematogenous or lymphogenous dissemination. Trauma is frequently mentioned and may undoubtedly act as a predisposing factor in all joint affections. Actual injury, however, causing traumatic arthritis, dislocations, and fractures can, as a rule, be determined by a definite history of trauma.

LOW-GRADE INFECTIOUS ARTHRITIS

Low-grade infectious arthritis is classed by many writers as a type of arthritis deformans. The author hesitates to subdivide further an already complex and incongruous subject; however, there are many cases of arthritis, more frequently of monarticular distribution, in which the pathologic process runs an indefinite course with gradual subsidence

and a return of the joint to normal. In other instances the joint may be more or less permanently impaired, but there is no tendency toward recurrence or subsequent involvement of other joints. From a practical standpoint, this monarticular type of arthritis differs from the atrophic, rheumatoid, or progressive polyarticular type of arthritis, and it is this group which will be considered under the term *low-grade infectious arthritis.*

Etiology.—The etiology is probably an infection by an attenuated virus derived from such foci as the teeth, tonsils, accessory nasal sinuses, genito-urinary tract, or gallbladder. Gonorrhea is also a probable causative agent, as often in the course of a chronic gonorrheal urethritis there may develop a low-grade arthritis. Possibly more light will be thrown on the actual nature of the process as biopsy and culture of specimens removed from the joints are more universally employed.

Fig. 83.—Deformity of knees in low-grade infectious arthritis.

Pathology.—The pathologic changes are those caused by any persistent irritant within a joint, as the joints like all other organs may give the same reaction to different agents. The changes may be divided into two types: the synovial and the osseous. In the synovial type there is a proliferation of the synovial villi, thickening of the capsule and more or less increase of fluid within the joint. Rarely the joint may be distended with the fluid. The periarticular tissues are not usually affected. This status may persist indefinitely as a monarticular affection, or rarely, as a bilateral or polyarticular affection. In the osseous type little is known of the changes in the tissues, as operative intervention is not indicated during the active process, but the roentgenogram demonstrates, after several weeks, a mottling of the articular extremities which resembles that caused by pyogenic infection, or there may be actual osseous destruction followed by ankylosis when

the infections are more virulent. If the process is not arrested, the roentgenogram also discloses destructive changes within the joint and proliferative changes and condensation suggestive of pyogenic infection.

Symptoms.—The process is usually confined to one joint, and rarely more than two joints are involved. The onset may be rather sudden or slow, but without severe constitutional symptoms. Occasionally, the process may begin as an acute infectious arthritis, which is followed by a prolonged subacute course after the subsidence of the acute symptoms. In the synovial type the knee is most frequently involved and on palpation lobulated masses, thickened capsule and an increase in fluid may be detected. The range of motion may be slightly limited or there may be no restriction. Pain is present after excessive or normal use, thus limiting activity. Slight swelling of the joints is observed frequently which may be only transitory. There is also a condition known as intermittent hydrops, occurring especially in the knee, evidenced by a synovitis, with excessive fluid, which remains for several days and then gradually subsides. This condition is either an infectious arthritis, or is probably due to some toxic poisoning from the intestinal tract or to food sensitization. In the osseous type the symptoms are pain, which may be slight or very severe, and limitation of motion, particularly in certain directions. In the hip joint the pain may be extreme and persistent, causing complete disability and leading to the production of contracture and ankylosis in malposition.

Fig. 84.—Infectious arthritis with proliferation and destruction of bone.

Diagnosis.—The diagnosis is made from the history of gradual onset, with continued swelling and pain in one joint. In children, symptoms suggestive of a tuberculous joint, but usually milder, are observed frequently, especially in the hip joint, but after a few weeks or months may entirely subside with a return to normal, or there may be more or less impairment. Syphilis of joints is diagnosed by the Wasser-

mann test and the disproportion between the clinical symptoms and the actual amount of destruction present in the joint. Progressive polyarticular arthritis, as a rule, produces greater atrophy of bone structure and more extensive deformity.

Prognosis.—The prognosis is usually favorable in the monarticular affections. In children, after subsidence of the process, recovery with perfect function or slightly restricted motion may be expected, while in adults, more or less permanent damage frequently occurs, and in rare instances, ankylosis may ensue.

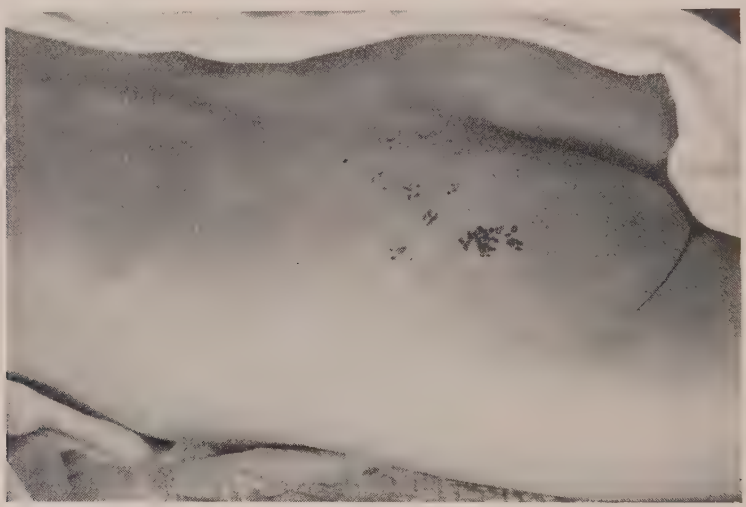


Fig. 85.—Herpes occurring in sciatica associated with infectious spondylitis.

Treatment.—Before any form of treatment is instituted, a thorough physical examination is required to discover any and all foci of infection. This requires the closest cooperation of specialists in the various fields of medicine and surgery. All probable foci of infection should be removed, but unfortunately, the removal does not arrest the process in a high percentage, possibly because the infecting organism is present already in the joint or joints. However, all authorities agree that any infectious process should be eradicated to prevent further invasion from the particular source, and also for the beneficial effect upon the health of the individual.

Autogenous vaccines, theoretically, should be employed, but their effects are rather uncertain. The same may be said of the injection of stock serums, foreign proteins, and other substances of this type. Amiodoxyl benzoate has been recommended by Young and Youmans, for intravenous administration, and is of value in some cases, though

not a specific. Recently, arthritis has been treated by vaccines prepared from organisms found to be agglutinated by the blood of the patient. Various organisms are tested with serum from the patient until one is found for which the blood has the strongest agglutinative quality. Vaccines are prepared from this organism and graduated doses are administered by hypodermic injection. This is a most complicated procedure, but excellent results have been reported by Hadjupoulos, Burbank, and others. In persistent synovitis with fibrosis of the capsule and proliferation of the villi, or when there is thickening of the capsule, operative measures are indicated. In mild cases, it may be possible to excise large fatty villi or redundant synovial membrane and capsule, but the results of such procedures are indefinite. Synovectomy, or the removal of the entire synovial membrane, offers the best chance of recovery.

Synovectomy is the removal of the synovial membrane or lining of a joint cavity for the eradication of various disease processes affecting this structure. The application is limited almost entirely to the knee joint, as the operation is of practical benefit in large joints only. First performed by Volkmann about 1877, in the treatment of tuberculosis of the knee joint, the operation has since been found unsatisfactory in the treatment of tuberculosis, but has found a more popular and practical use in the chronic infectious and traumatic types of arthritis, and in allied conditions where primary disease of the synovial membrane is the chief cause of the disability. The author feels that with our present knowledge of arthritis, the indications for synovectomy should be limited to infectious arthritis, traumatic arthritis, syphilitic arthritis, osteochondromatosis, and benign tumors arising from the synovial membrane. The problem, after the active process has subsided, is a mechanical one rather than removal of infection from those joints in which the synovial membrane alone or in combination with the cartilages has been irreparably damaged. Clinically, there are certain types of joints not suitable for synovectomy. In acute pyogenic arthritis and in those cases classed as hypertrophic with marked bony changes in the knee and a history of recent activity in other joints, the prognosis is doubtful. Permanent results can not be hoped for if the disease process is active or progressing.

Technic.—A long incision is made on the antero-internal aspect of the thigh, parallel with the quadriceps tendon, patella, and patellar tendon, terminating below and medial to the tibial tubercle. The superficial and deep fasciae are incised and the joint entered from above downward through the junction of the vastus internus and rectus femoris

muscles, the anterior capsule of the knee and patella and the capsule and patellar tendon. The patella is retracted outward with the quadriceps and patellar tendon, thus giving sufficient exposure to the entire joint. After the joint has been entered the synovial membrane is carefully examined and a section removed for microscopical examination. A line of cleavage is defined between the synovia and the capsule. Beginning at the upper angle of the joint, the entire synovial membrane is removed by block dissection from the inner, outer, and anterior aspects of the joint; both semilunar cartilages are also removed. The synovia in the posterior compartment is not accessible and may usually be left without fear of further deleterious effect. In rare instances, the crucial ligaments may be severed for removal of the synovia from the posterior culdesac.

Active motion should be instituted at the earliest time possible, often the second or third day after operation. A Thomas splint, hinged at the knee, applied immediately after the operation, has been found helpful. The splint is suspended from an overhead frame, and active motion can be aided by pulleys under the control of the patient's own hand. Flexion contractures can also be prevented in this way. Physiotherapy, consisting of light and massage, about the seventh or tenth day aids in the absorption of the exudate and promotes an early return of function.

PROGRESSIVE POLYARTICULAR ARTHRITIS

Progressive polyarticular arthritis is classified as a special type because the course is indefinite and the process does not tend to be arrested. The affection is usually described as a type of arthritis deformans, but, from its clinical course, the process would more probably seem to be an infection, and consequently, is best classed as a type of infectious arthritis. The term *arthritis deformans* may well be applied to any joint affection which may induce permanent malpositions or deformity, and should be discarded from the nomenclature. It is doubtful whether distinction should be made between the polyarticular and monarticular types of low-grade infectious arthritis, as it is quite possible that the polyarticular progressive type is the same infection as the monarticular, but in a more exaggerated form which does not respond to treatment. The etiology is possibly the same, but the polyarticular type is more progressive and persistent. Progressive polyarticular arthritis is also known by the following synonyms: proliferative type of arthritis deformans or proliferative arthritis, rheumatoid arthritis, and infectious arthritis. According to the classification of Nichols and

Richardson, the proliferative type tends to destroy the joint cartilage, and leads to ankylosis of the adjacent joint surface; whereas the degenerative type destroys the joint cartilage and produces deformity without ankylosis. The term *chronic rheumatism* is applied to any and all joint diseases which pursue an indefinite course, except tuberculosis, and is, therefore, confusing and has no meaning.

Etiology.—The infection is hematogenous in origin from a disease focus elsewhere in the body. Other etiologic factors, as metabolic disturbances and intestinal toxemia, are suggested as possible causes, and there is also a neurotic theory. Worry, overwork, and exposure to cold are supposed to be predisposing factors. The process occurs more frequently in adults under forty, rarely in children or in elderly persons. In children the onset is usually sudden with enlargement of the lymphatic tissue and is known as Still's disease. The course is indefinite and rarely terminates spontaneously.

Fig. 86.—Still's disease with polyarticular involvement and deformity.

Pathology.—The affection usually begins as a low-grade inflammatory process in the soft structures of the joints, with gradual proliferation of the synovia and atrophy of the bone. One joint may be invaded at the beginning, and the process remain monarticular for a long period of time, but later other joints become involved, or the process may begin as a polyarticular affection. Months or years may elapse before the articular surfaces are involved, but there is a constant extensive osteoporosis in the extremities of the bones forming the articulation which become ready prey to the destructive process. Coincidentally, the joint becomes flexed and later there is actual invasion of the articular surfaces and bone. After bone destruction there may be subluxation or actual dislocation with distortion. The process often terminates in fibrous or bony ankylosis.

Symptoms.—The onset is usually slow and insidious, but rarely may be sudden, with all the symptoms of an acute infectious arthritis of pyogenic origin, or may possibly be the sequela of an acute pyogenic

infection. Pain with periods of remission is present in the joint or joints. Acute exacerbations may occur, accompanied by a rise in

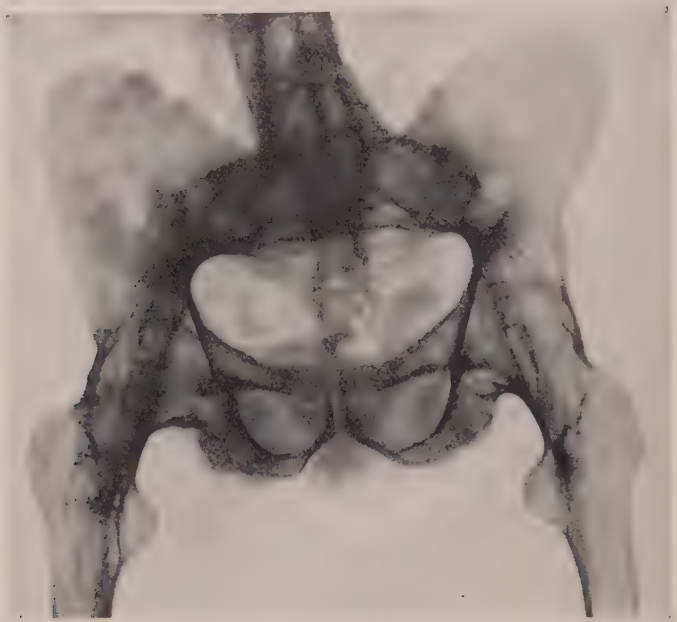


Fig. 87.—Atrophic arthritis with ankylosis of lumbar spine, sacro-iliac joints and hips.

Fig. 88.—Deformity of hands in progressive polyarticular arthritis.

temperature, or a new area of another joint may become involved, and coincidentally there is an elevation of temperature for a few days

which gradually subsides. There is considerable swelling of the joint which is accentuated by extreme atrophy of the muscles and soft structures on both sides. The skin, being glossy and shiny, presents an atrophic appearance.

Diagnosis.—Infectious arthritis of the progressive type is recognized by the fact that in low-grade infectious arthritis only one or two joints are involved, while the progressive type is polyarticular. Deformities also are not so extensive in low-grade infectious arthritis, nor osseous structures so atrophic, and function is not impaired to such a degree as in progressive polyarticular arthritis. As previously mentioned, the conditions may be the same, but as there frequently occurs a joint affection, which tends to recovery or runs a definite course, the distinction is easily made. Differentiation of progressive polyarticular arthritis from tuberculosis and other low-grade arthritic processes is made by the symptoms and the roentgenogram, but the diagnosis is difficult and, at times, impossible until other joints become involved. A polyarticular arthritis is often associated with pulmonary tuberculosis and in all probability is an infectious arthritis due to secondary infection. Progressive polyarticular arthritis is differentiated from polyarticular syphilitic joint affections by the Wassermann test and by the fact that in syphilis the objective manifestations are in excess of the subjective symptoms.

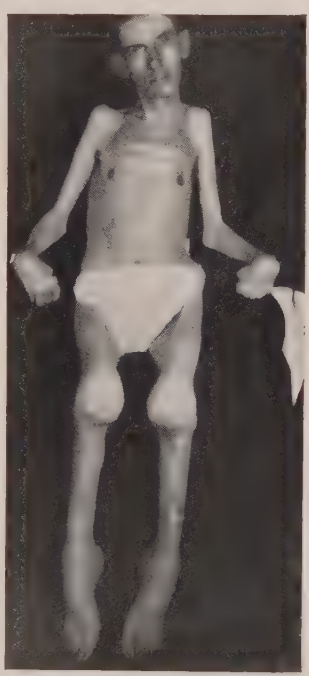


Fig. 89.—Progressive polyarticular arthritis with deformity.

Prognosis.—The prognosis is always doubtful, though arrest of the process may, at times, be accomplished by combined medical, surgical, and mechanical treatment to reestablish function, or recovery may occur spontaneously in spite of all treatment.

Treatment.—The treatment consists of the elimination of all infected foci; no compromise must be made when a focus can be completely excised. Dietetic measures are of value, but must be adapted to the individual patient. Autogenous vaccines, foreign protein injections, and various serums as those recently advocated by Burbank and Hadjopoulos, are worthy of trial; also, various drugs by mouth

or subcutaneous and intravenous injections have been recommended. Light therapy and physiotherapy efficiently administered are undoubtedly of material value and should be routinely employed, combined with other forms of treatment. Active and passive exercises are of great value, but must not be pushed to the point of painful reactions; otherwise progress will be impeded.

The employment of fixation apparatus or traction by Buck's extension may often give relief. Malposition and deformities should be corrected by apparatus. In those with deformity in whom the destructive process is not too far advanced, the one measure offering the greatest hope of definite improvement is gradual correction; for example, in the majority of cases the knees become flexed, rendering walking impossible, although a practical range of motion may be present. In such cases, correction may be obtained by the use of an apparatus for gradual extension. Malposition of the ankle, hips, and joints of the upper extremities may be corrected by similar apparatus. Dislocations, if slight, may be corrected by apparatus, but if complete, must be reduced under anesthesia. The correction of deformity not only improves function, but has a distinctly beneficial effect on the morale of the patient by permitting active use of the part. After the contractures have become organized, tenotomy and capsulotomy are required. Synovectomy has been found beneficial in some cases of polyarticular arthritis, although the operation is usually indicated only in those cases in which a single joint is involved. Arthroplasty has also been employed in a small number of cases, and while improvement may be secured, the procedure in such conditions must be regarded as in the experimental stage.

HYPERTROPHIC ARTHRITIS (OSTEARTHRITIS)

Etiology.—In all probability hypertrophic arthritis or ostearthritis is due to many different causes. There is, of course, as in all types of arthritis, an infectious theory. Hypertrophic arthritis may undoubtedly be caused by long-continued irritations and is usually observed in those above forty years of age and may be considered to some extent the result of natural wear and tear of normal life, and also to toxemia or impaired metabolism of advancing age. In fact, in elderly persons, gross changes without symptoms are often apparent by the roentgenogram. Professional athletes and those whose occupations are laborious may show hypertrophic arthritis at an early age.

Pathology.—The pathology is a gradual wearing away of the cartilages with eburnation of the articular surfaces so that there may be

osseous contact. On the margin of the articular surfaces outgrowths of bone are formed, causing the so-called osteophytes, which may also be manifested as warty excrescences on the articular surfaces. At times these osteophytes may break off into the joint as loose bodies, or loose bodies may be exfoliated from the articular cartilage and impinge between the joint surfaces. There is always some inflammatory reaction of the synovia and at times excessive proliferation of the villi. In advanced cases there is fibrillation of the articular cartilage denoted by a yellowish tinge. The process frequently begins in the distal joints, as the metatarsophalangeal joints or the interphalangeal joints of the hands. In the upper extremity nodular protuberances on the fingers, known as Heberden's nodes, are frequently observed. The larger joints, however, do not escape. Occasionally osteochondromatosis or synovial osteochondroma may be associated with hypertrophic arthritis.

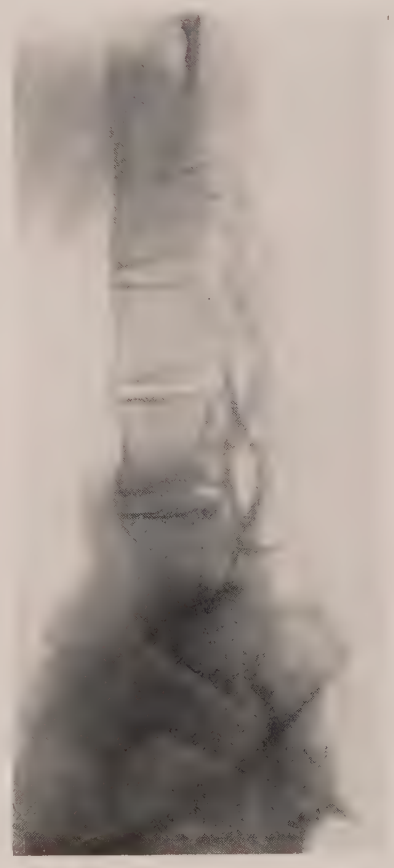


Fig. 90.—Hypertrophic arthritis with production of osteophytes and ankylosis of lumbar vertebrae.

The roentgenogram shows, first, a proliferation about the margins of the joints, which may appear as small pointed processes, the so-called lipping, or, in exaggerated cases, there may be a massive projection of bone about the margins of all the articular surfaces. The joint space may be diminished from destruction of the cartilage and there may be loose bodies present within the joint cavity. As the process advances the exostoses increase in size, the articular surfaces become more irregular and the joint space progressively less until the outline of the joint is completely distorted. Ankylosis seldom occurs, although it may be apparent in the roentgenogram.

Symptoms and Diagnosis.—The onset is always gradual, beginning in persons around middle age. Pain is a constant symptom and is

usually aggravated by activity, although pain may persist during rest. There is a progressive stiffness in the joints which is more apparent after rest and disappears, to some extent, on use. Crepitation may be apparent on motion not only to the patient, but also may be audible to others nearby. The pathologic changes may be present in joints without symptoms and frequently the appearance of symptoms is induced by trauma. The diagnosis is easily made from the history and physical findings and the roentgenogram, as a rule, is characteristic.

Treatment.—The treatment in hypertrophic arthritis is in some respects the same as that of progressive polyarticular arthritis. Surgery for the elimination of foci, dietetic measures, and the prevention of deformity and malposition are indicated. It is difficult to determine the actual value of any therapeutic measure, as there may be spontaneous improvement, and undue credit may be ascribed to the last form of treatment employed, whatever that may be.

Operative measures for the removal of large marginal overgrowths of bones are at times attended by relief of symptoms, and are occasionally worthy of trial, but are of no value so far as arrest of the process is concerned. The removal of loose bodies is indicated when there are symptoms of impingement between the articular surfaces. Rarely, in those cases in which there is associated excessive synovial proliferation, synovectomy is indicated. Arthroplasty, or the reconstruction of a new joint, may be attempted, but is not beneficial in a large proportion of cases. However, with the development of a more perfect technic, possibly some relief may be secured. Much can be accomplished if sound surgical judgment is used in the selection of the method to be employed for the individual patient.

Monarticular affections that do not respond to conservative measures may at times be relieved by surgery. Reconstruction operations on the hip joint have been reported successful when that joint alone is involved. The method most commonly employed is that described by Whitman for the treatment of ununited fracture of the neck of the femur, which is described in the section on Fractures. In some instances, fusion of the hip joint is probably the operation of choice. The extra-articular technic, described in the section on Tuberculosis, may be employed.

INFECTIOUS SPONDYLITIS

Infectious spondylitis is a chronic form of ankylosing arthritis of the spine. For the convenience of description, the spinal form of infectious arthritis is treated separately, but it must be clearly understood that no sharp line can be drawn between spondylitis and arthritis

of the peripheral joints owing to the existence of endless intermediate or transitional forms. All that can be alleged in distinction is that in the vertebral variety the brunt of the morbid process falls upon the spinal column, the disease in some instances being strictly confined thereto, but more commonly implicating at the same time, to a variable degree, the joints of the limbs. The sacro-iliac joints, in particular, are frequently involved in the infectious process. There may be a general involvement of one or all regions of the spinal column or the affection may be confined to a single segment, a localized spondylitis resembling or in reality being the same pathologic process as typhoid spondylitis. Spondylitis may occur in several forms as does low-grade infectious arthritis in other joints. Atrophic or hypertrophic changes may predominate, depending to some extent upon the age at which the process begins. Hypertrophic spondylitis or osteartlıritis is common in those past forty years of age as a result of natural wear and tear of life, but may also occur in young individuals. Atrophic spondylitis is seen almost exclusively in elderly persons.

Etiology.—The facts at our disposal do not indicate that there is any difference between the etiology of spondylitis and that of other forms of low-grade infectious arthritis. Atrophic changes in the spine are frequently seen in those of advanced years, and are regarded as one of the common symptoms of senility, and the majority of the patients are of the male sex. The history frequently shows the patient to have been subjected to prolonged exposure to dampness, cold, and sudden changes in temperature. Heredity is thought to be a predisposing factor in rare instances. Some authorities claim that environmental circumstances, mechanical causes, and traumatisms are in some obscure way related to the vertebral type of arthritis; yet, by the majority, these factors are regarded as causative only insofar as they produce direct damage to the nervous system or favor the occurrence of an infection. Marie and Aste suggest that the condition is of neurotrophic origin, the nutrition of the vertebrae becoming impaired secondarily to contusion of the spinal cord.

Pathology.—The intervertebral disks undergo fibrillation and absorption to a greater or less extent. The lateral aspects of the vertebral bodies become the site of new bony outgrowths which, fusing with similar formations on neighboring segments, assume a somewhat stalactitic form, uniting the vertebrae one to another. Usually these longitudinal osseous bands are placed symmetrically, covering, according to their width, the space between the transverse processes and the edge of the anterospinal ligament. In some cases the intervertebral

disks are entirely replaced by bone, thus causing, in rare instances, a condition of true bony ankylosis of the bodies of the vertebrae. The roentgenogram may show a smooth mass of bone extending over the vertebrae, as if a plastic exudate had been allowed to flow down the entire length of the spine and had consolidated like ice forming in a fall of running water. The bony changes in the vertebrae are predominantly of a rarefying or atrophic character. The spine becomes rigid throughout its entire length, or the rigidity may be confined to only a few of the spinal segments. In the latter case the lower dorsal and lumbar regions suffer more frequently. When the process is localized and only one intervertebral disk is affected, the roentgenogram shows crescent-shaped lamellae of bone joining the vertebra to its adjacent fellow. In some the bony bridge may be complete and connected by only one extremity to the vertebral body, and at times there may be no apparent union of either extremity to the bodies, which is probably explained by assuming that the process was fibrous in the early stage with later ossification. The bony lamellae may connect the bodies at their margins, the so-called lipping, or may extend from the center of the articular surfaces. The bodies of the other vertebrae may show no abnormality in shape, size or structure. The pathologic changes are as variable as in the peripheral joints and there may be repeated acute attacks or a steady progress of the disease. In the dorsal spine with involvement of the costovertebral joints the ribs may be fixed to the vertebrae and to the sternum, and the thorax becomes immobile.

Fig. 91.—Infectious spondylitis with rounded kyphos and rigidity of spine.

Symptoms.—The most striking symptom is the spinal rigidity which is usually associated with a rounded kyphos, the degree of the deformity depending upon the area of the spine involved. In rare instances spondylitis begins suddenly, pain and stiffness of some portion of the spinal column appearing quickly after some traumatism, or following exposure to cold or dampness. However, in the majority of instances, the condition of spinal rigidity develops slowly and in-

sidiously, and not infrequently its presence is overlooked owing to the fact that the pains are often referred to the extremities rather than the affected portions of the spine. The larger joints, particularly the hip and shoulder, may be involved in an associated arthritic process. With the fixation of the ribs, the expansion of the chest becomes more or less restricted and respiration is largely abdominal in type. Paroxysms of pain occur, during which muscular spasm is present and radiating pains in the lower extremities may cause great distress. Abnormal neurological findings are frequent, due to compression of the nerve trunks in the vertebral foramina. Areas of numbness, or paresthesia, may be present, and the reflexes, both superficial and deep, may show extreme variability; they may be normal, exaggerated, or absent. Kernig's sign may be positive. Constitutional symptoms are, as a rule, not evident. There is no elevation of temperature or alteration in the blood count.

Diagnosis.—The diagnosis of infectious spondylitis in its earlier stages is often difficult, but can be made if the following characteristic symptoms are kept in mind. The disease is one of youth and early middle life; most frequently met with in men, but rarely in women. There is pain and progressive stiffness of the spine, leading to fixation of large sections with the production of a rounded kyphos, and often associated with ankylosis of the hips, shoulders, and costovertebral articulations. Nerve symptoms, such as root pains, atrophy of muscles, and variations of sensation and motion, are associated, and there may be a history of previous arthritic lesions elsewhere in the body. Infectious spondylitis must be differentiated from tuberculosis of the spine, malignant tumors of the spine, typhoid spondylitis, and traumatic spondylitis. In the differential diagnosis the roentgenogram is of value, particularly in the later stages, as a generalized involvement of the spine will be shown with loss of density, narrowing of the interspaces, and the production of osteophytes along the margins of the vertebral bodies.

Treatment.—The institution of treatment as early as possible is important, as the prognosis varies in direct proportion with the duration of the disease when treatment is begun. All possible sources of focal infection or absorption must be eliminated. Fixation is of value by lessening pain and preventing the gradual increase of deformity, and must be prolonged indefinitely until the disease is arrested, or until the symptoms subside spontaneously. Immobilization may be accomplished by plaster-of-paris jackets applied with or without traction, spinal braces, or by recumbency on a Bradford frame. Fusion operations

on the spine are rarely indicated, but may be carried out, as described in the section on Tuberculosis, the technic being appropriate to the region of the spine affected.

GOUT

Gout is a disease characterized by disturbance of the purine metabolism and manifested clinically by periodic attacks of acute inflammation of the joints, and the formation of tophi by the deposition of monosodium urate in the tissues. The exact etiology is unknown, though hereditary tendency, excessive use of alcohol, overeating, and lack of exercise are predominant factors. The disease occurs more frequently in men than women and is most common in middle life.

During the acute attacks monosodium urate is deposited in the synovial membrane and occasionally in the marrow and periosteum of the surrounding bones, the tendon sheaths and bursae, and in the synovial fluid. The first metatarsophalangeal joint is most commonly affected, though the larger joints, as the knee and the joints of the upper extremity, may at times be involved. Tophi are found chiefly in the cartilages of the ear. From the joint fluid the uric acid penetrates the cartilages which may be found at postmortem to contain deposits of white crystals embedded in the cartilage. The synovial membrane first presents the appearance of acute inflammation, and the cartilage also shows a tendency to inflammatory degeneration and erosion. Later there is a permanent thickening of the synovial membrane. There is but little tendency to suppuration, unless the calcareous deposits ulcerate through the skin by pressure. The chief symptom is the occurrence of repeated attacks of acute arthritis. The great toe is usually affected and the attacks commonly begin during the night. The attacks last two or three days and gradually subside. A history of repeated attacks with periods of remission is characteristic, as is also the location of the disease in the great toe. The finding of tophi and excess uric acid is diagnostic. Differentiation must be made from the other low-grade affections of joints. The absence of fever in gout differentiates it from an acute arthritis. The peculiar distribution, recurrences, and exacerbations with presence of tophi will distinguish it from the other low-grade infectious forms of arthritis, syphilis, and tuberculosis, and other types of destructive arthritis will be identified by the presence of the destructive changes seen in the roentgenogram.

Treatment is by diet, reducing the purine content of the food, such as sweetbreads, liver, and kidneys, and limiting the use of alcohol, coffee, and tea. A moderate amount of outdoor exercise should be

taken between attacks, and certain drugs, such as salicylates, colchicum, etc., may be of value. Surgical treatment is not indicated except for removal of large deposits of urates which may interfere mechanically with function of the joint.

SYPHILIS OF JOINTS

Manifestations in joints occurring as a mild arthritis are occasionally observed during the secondary stage of syphilis, but are of minor significance. Practically, syphilis of the joints is a complication of the third stage only, and must be regarded as a tertiary lesion. Syphilitic arthritis in children results from hereditary transmission, while in adults acquired syphilis is the most frequent cause, although late manifestations of congenital syphilis are not infrequently observed. The general impression prevails that in children the joints are more frequently involved than the bones, but from the author's records the incidence is about equal. Any joint may be involved, but the knee is more frequently affected. The process may be confined to one joint or there may be a polyarticular invasion which occurs more frequently in children than in adults. Polyarthritis is characterized by gradual invasion of the joints and is of little interest from a surgical standpoint. Syphilis of the spine probably occurs more frequently than is generally recognized.

Pathology.—The process may begin as a primary arthritis or may be extra-articular, beginning in the epiphysis, and invading the joint by continuity from an adjacent periostitis or osteomyelitis. When the process is confined to the joint, the capsule and the synovial membrane may be markedly thickened with increase in fluid within the joint, a simple chronic synovitis. There may be also the same reaction within the joint as is caused by any constant irritation, demonstrated by proliferation of the villi with formation of large masses of low-grade fibrous and fatty tissue. If the process is not arrested, there will be erosion of the cartilage and osseous destruction forming small punched-out areas. Gummata may develop in the region of the epiphysis with the formation of cavities which may break through into the joint, causing gross incongruity and deformity. When there is syphilitic osteomyelitis, the joint may also be invaded by continuity from the shaft of the bone, causing separation and disintegration of the epiphysis with pathologic fracture. Secondary pyogenic infection, with the usual constitutional symptoms and abscess formation, may be a complication. The process is finally arrested spontaneously with more or less damage to the joint, but bony ankylosis rarely occurs.

Symptoms.—A history of syphilis is often available in adults, while in children the stigmata of congenital syphilis may be evident. The subjective symptoms are much less than the existing pathology would indicate until there has been extensive destruction. Pain, local tenderness, limited joint motion, and muscular atrophy of the limb are not pronounced until there is osseous destruction, when all symptoms usually become acute. The joint manifestations are of three types: (1) exudative or synovial, (2) proliferative, (3) destructive.

Fig. 92.—Syphilis of ankle with punched-out areas on the articular surfaces of tibia and astragalus.

Fig. 93.—Typical syphilitic dactylitis, one of the manifestations of polyarthritis.

On inspection, in the exudative or synovial type, the joint is distended with obliteration of bony landmarks. Fluctuation and increase in thickness of the capsule and synovial membrane may be detected on palpation. The picture is that of a chronic synovitis, and motion is slightly limited only when there is an excess of fluid. In children, a persistent hydrops of both knees is not uncommon. Polyarthritis of syphilitic origin in children presents rather typical osteochondritic changes with joint hypertrophy that is less painful than other joint affections. In adults, syphilitic polyarthritis is rare, but may be determined by the history and the physical and clinical findings. Local

heat may be slightly elevated, and, as a rule, there is no muscular spasm.

In the proliferative type the swelling may be slight or pronounced. On palpation only a small amount of fluid may be detected. Definite thickening or induration of the capsule or lobulated masses within the joint may be noted. Pain may be present at times, but there is slight, if any, limitation of active or passive motion. General hypertrophy of one or more bones comprising the articulation is present when the bone is involved by a syphilitic periostitis, and may be detected on palpation.

In the destructive type pain is severe, tenderness is pronounced, and motion is restricted by muscular spasm. However, the extent of osseous invasion without acute symptoms is often astounding. When the invasion is from without, local symptoms are not usually pronounced until the process has involved the joint.

Fig. 94.—Syphilis of elbow joint.

Roentgenoscopy.—Visualization of the process by the roentgenogram is difficult to describe, but there are certain manifestations which are most suggestive of syphilitic arthritis: (1) An increase in density of one or more of the bones of the articulation, often with gross hypertrophy, which is an extension of bone syphilis by continuity; (2) proliferation of the periosteum on one or more of the bones forming the articulation, proximal to and extending a short distance from the joint surface; (3) definite punched-out areas on the articular or nonarticular surfaces; (4) a fuzziness of the joint surface, irregular opaque areas beneath the articular cartilage, and irregular, loose, highly refractile particles within the joint; (5) a large opaque area within the cancellous bone a short distance from the articular surface; (6) extensive destruction, without atrophy of bone tissue, unless the arthritic process is complicated by secondary infection.

Diagnosis.—The differential diagnosis can often be made by the clinical manifestations, though confirmation by the Wassermann test must always be secured. In the early stage, or before involvement of osseous tissue, when comparison is made with any other affection remotely resembling syphilis, the objective manifestations are excessive

when compared with the subjective symptoms of pain, tenderness, and muscle spasm. After there has been osseous disintegration, with the development of the acute symptoms, differentiation from tuberculosis may be clinically impossible, but the roentgenogram and Wassermann test will distinguish the conditions in the majority of cases.

Syphilis of the bones, especially of the tibia, is often present without symptoms, and may be co-existent with joint syphilis. Therefore, routine roentgenologic examination of the tibiae may demonstrate typical syphilitic periostitis which presents additional diagnostic evidence. Syphilis and other joint affections are both of frequent occurrence; consequently, it must be remembered that both may exist coincidentally in the same individual, and that a positive Wassermann is not prima facie evidence that an existing joint lesion is of syphilitic origin. The author made a close study of 33 joint lesions in which the Wassermann test was strongly positive, but the local manifestations indicated that the arthritis was due to other etiologic factors. In 17 of these, antisyphiltic treatment was given without the slightest beneficial effect upon the local process; the remaining 16 were lost sight of or were treated elsewhere. The blood Wassermann is conclusive in a high percentage, and, therefore, the spinal fluid test is rarely necessary, except in parasyphilitic lesions. In 100 cases of undoubted bone and joint syphilis the blood Wassermann was found positive in 88 and negative in 12. In those with congenital syphilis all were positive. The Kahn, luetin, and other tests are also of value and are often employed for confirmation. In those in whom the lesion is indicative of syphilis, but the blood and spinal fluid Wassermann tests are negative, the therapeutic test should be employed. This consists in the administration of intensive antiluetic treatment with observation as to the beneficial action upon the local lesion.

Treatment.—The salvage of a good functional joint depends upon the degree of osseous destruction; with efficient treatment, recovery with excellent function may be expected, unless the process has caused destruction of the articular surfaces. The treatment consists of intensive antisyphilitic measures which must be continued over a long period of time. Arsphenamine intravenously has a more definite beneficial effect upon the local process; other agents, as neoarsphenamine, sulpharsphenamine, and bismuth, are also employed when arsphenamine is contraindicated. Mercury and the iodides must also be administered concurrently. Congenital syphilis is less amenable to the treatment than acquired syphilis, and polyarthritis of syphilitic origin is even less responsive than the monarticular form, usually

requiring a prolonged course of treatment with massive doses of antisyphilitic drugs. Bismuth is said to have a more definite action upon hereditary syphilis. Apparatus may be indicated for the correction and prevention of deformity and malposition, and after the elimination of the constitutional syphilis, deformities should be corrected by surgical means as in the residual stage of acute infectious arthritis.

TROPHIC AFFECTIONS OF JOINTS

Parasyphilitic Arthropathy.—Trophic affections of the joints are not of themselves syphilitic processes, but are manifestations caused by syphilis of the spinal cord, and are more frequently observed twenty or thirty years after the occurrence of the primary infection. Arthropathies are rarely seen in young persons, although the author has observed typical Charcot joints in a negro boy of sixteen years. Other spinal lesions, as myelitis and syringomyelia, rarely may induce the same phenomena. Trophic affections of joints are of surgical interest chiefly from the standpoint of differential diagnosis. The knee is more frequently affected than any other joint, and occasionally both knees are involved. The frequency of involvement of the spine and hip is greater than is generally recognized. Charcot joints of the upper extremities, especially of the shoulder, are often overlooked.

Fig. 95.—Charcot knee with increase in size and bowing of leg.

Fig. 96.—Charcot elbow.

Symptoms.—The first symptom is swelling of the joint with slight laxity, which gradually increases until there is complete disintegration with spurious and massive formation of bone and cartilage. As the process advances there is also loss of ligamentous support and the joint may be flail with excess mobility in all directions, or there may be actual dislocation. Pain is rarely persistent in the affected joint, but may be referred to the region corresponding to the lesion in the spinal cord. Tenderness on palpation is rarely present. Argyll Robertson pupil, loss of knee reflexes, Romberg's sign, and diminished sensation in the lower extremities are well known manifestations of cerebrospinal syphilis. Other symptoms of tabes dorsalis, as girdle pains, can be as-

Fig. 97.—Charcot joint with massive destruction of joint and subluxation of tibia. Note loose bodies present in joint cavity. Anteroposterior view.

Fig. 98.—Same as Fig. 97. Lateral view.

certained from the history. Secondary pyogenic infection in a Charcot joint is of infrequent occurrence and is a serious complication. The symptoms are those of an attenuated pyogenic infection with slight elevation of temperature, and the formation of large and fluctuating abscesses.

Diagnosis and Prognosis.—The diagnosis can always be made by the classical symptoms and manifestations. The blood Wassermann may be negative and the spinal fluid Wassermann positive; therefore, a routine examination of the spinal fluid should always be made, including the cell count and other tests for syphilis. The prognosis becomes

more uncertain with the advance of the local and spinal lesions. The process may at times be arrested by intensive treatment, but there is little to be expected from surgical procedures.

Treatment.—The problem of constitutional treatment is in the domain of neurosyphilis, and is, therefore, not pertinent to this discussion. After arrest of the process, if such can ever be determined, operations for the purpose of inducing osseous fusion may be indicated, but should not be attempted if there is much loss in skin sensation over the affected joint. The only treatment of definite value is suitable apparatus constructed to meet the requirements of the individual joint. In the ankle, a leather corset from toes to just below the knee, reinforced with steel, gives the most efficient support. In the knee, a leather corset, extending from ankle to groin, but with a joint at the knee, permits such degree of normal motion as may be feasible. In the hip, the only effective appliance is a Thomas caliper spint, with takes the weight of the body from the hip, and to which may be added a leather corset which encompasses the pelvis and thigh. The spine is treated by a brace adjusted to the requirements of the region effected.

OSTEOCHONDRITIS

(Epiphysitis)

Certain of the intra-articular and extra-articular epiphyses may be involved in an abnormal process which presents such characteristic manifestations that it may be regarded as a clinical entity. The anatomical location subjects the epiphyses to injury by external force and by muscular contraction. The condition may be confined to one epiphysis or may involve two or more in succession or simultaneously. Epiphysitis occurs more frequently in late childhood or near puberty, and boys are more often affected than girls. The etiology is unknown, but from the evidence available trauma is a prominent factor. There is also an infectious theory, and congenital malformation has been regarded as a predisposing cause. When the intra-articular epiphyses are involved, the affection may closely resemble disease of the joints; involvement of the extra-articular epiphyses, *i. e.*, the tibial tubercle and the posterior epiphysis of the os calcis, produce less obvious joint symptoms. The affection is possible in every epiphysis, but will be described only in those in which the manifestations have been observed more frequently.

Osteochondritis of the Metatarsal Bones
(Köhler's Disease)

Osteochondritis of the heads of the metatarsal bones was first described by Köhler and is commonly known as Köhler's disease. Freiberg designated the affection as infraction of the head of the second metatarsal bone, as a majority of patients give a history of stubbing the foot while running up steps or in such games as tennis. As the second metatarsal bone is longer, it is more exposed to trauma and, therefore, is more often involved. The author reported the affection as occurring in the head of the third metatarsal bone in one case, and since that time two others were observed in which the third metatarsal bone was affected, and in one the fourth.

Fig. 99.—Osteochondritis of head of second metatarsal with typical corpora libera in the joint.

Pathology and Symptoms.—The process always begins during adolescence, but may be first detected by the surgeon at any age thereafter. If first observed in an adult, there is often a history of injury in late adolescence with repeated attacks of pain and tenderness. The roentgenogram shows a flattening of the head, with increase in transverse diameter, proliferation of the epiphysis, and free bodies within the metatarsophalangeal joint. After maturity, the epiphyses are obliterated, but the articular surface remains flattened and irregular. Axhausen observed necrotic areas microscopically and regarded them

as tuberculous. This has not been confirmed and others have regarded these areas as due to aseptic or pressure necrosis. The symptoms are exquisite tenderness over the head of the bone and pain on walking. Slight enlargement may be apparent on inspection. On palpation there is definite enlargement, with tenderness more exaggerated on the dorsum of the foot, and pain is severe when the head of the bone is compressed between the thumb and forefinger.

Treatment.—The treatment consists of an elevation just behind the head of the affected metatarsal bone, as in the orthopedic treatment of metatarsalgia. If this affords no relief, the head of the bone should be excised. A longitudinal incision is made over the dorsum of the affected bone and the metatarsophalangeal joint. The extensor tendons are retracted and the distal extremity of the bone is exposed and denuded of periosteum by a blunt elevator. The shaft is severed about $\frac{1}{2}$ inch proximal to the head with bone-cutting forceps; the lower fragment is then dissected and removed, after which the wound is closed. The continued use of the elevation is often advisable for a few weeks after the operation.

Fig. 100.—Köhler's disease of the scaphoid bone. Note flattening and increased density. Anteroposterior view.

Osteochondritis of the Scaphoid Bone (Köhler's Disease)

The scaphoid bone may be involved in a process which runs practically the same clinical course as epiphysitis. The affection occurs in young children, usually between the ages of three and six years, and is probably the result of trauma. The first symptoms are slight pain in the foot and a limp. On examination there is tenderness over the affected scaphoid. The midtarsal joints show evidence of irritation and limitation of motion, especially on adduction. The roentgenogram shows the scaphoid bone flattened in the anteroposterior direction with much the appearance of a coin, except that the circumference is fuzzy. In exaggerated cases a cast may be required for a few weeks, but a simple arch support as in the treatment of flatfoot is usually sufficient.

Fig. 101.—Same as Fig. 100, lateral view.

Epiphysitis of the Scaphoid Bone

In children about twelve years of age there is often an irritation of the inner aspect of the scaphoid which is apparently due to a supernumerary bone adjacent to the scaphoid. As this condition is at times associated with generalized epiphysitis, it is termed an affection of the epiphyses, though no epiphysis in this region is recognized by anatomists. The symptoms are similar to those of flatfoot, and the roentgenogram demonstrates the typical irritation of the supernumerary bone and the adjacent portion of the scaphoid bone. The treatment consists of adhesive strapping followed by an arch support. Recovery may be expected in all cases.

Epiphysitis of the Os Calcis

Epiphyseal irritation may be observed in the posterior epiphysis of the os calcis and is known as apophysitis. The process as demon-

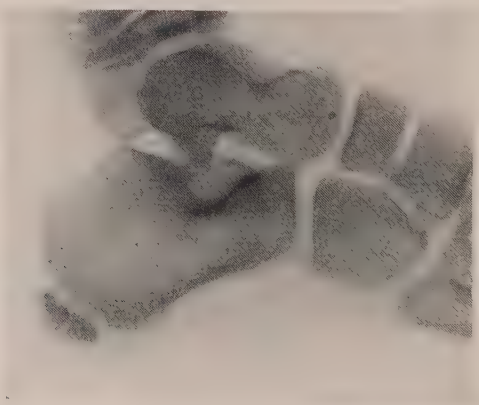


Fig. 102.—Epiphysitis of os calcis.

strated by the roentgenogram is pathognomonic. The treatment consists of removing the counter from the heel of the shoe so as to decrease pressure on the heel. The counter is the stiff leather reinforcement placed between the inner lining and the outer covering to give shape to the posterior half of the shoe.

Epiphysitis of Tibial Tubercle
(Osgood-Schlatter's Disease)

Epiphysitis of the tibial tubercle is of common occurrence about the age of puberty, being observed more frequently in boys than girls. The affection is usually unilateral, but may rarely be bilateral. On examination, there is a definite enlargement of the tibial tubercle, slight pain and tenderness, and rarely edema. The roentgenogram shows a proliferative and degenerative process of the tibial tubercle, often with separation of the epiphysis, which is quite characteristic.

Fig. 103. — Epiphysitis of tibial tubercle.

Treatment.—There is no material disability and no local treatment is indicated, though operative intervention has been advocated. Complete recovery may be expected in all cases, though one or more years may elapse before the symptoms entirely subside.

Coxa Plana

Coxa plana, as the term implies, is a condition characterized by flattening of the head of the femur. The affection was first described by Legg and later by Perthes and Calvé. The affection was designated by Perthes as osteochondritis deformans juvenilis, but the term "coxa plana," suggested by Jansen, is more convenient if not appropriate, as it conforms to the nomenclature of other affections of the upper extremity of the femur. Undoubtedly this affection was previously regarded as tuberculosis, which accounts for many reputed cures of tuberculosis of hip joints by various kinds of treatment.

Etiology.—Coxa plana is an affection of early childhood, occurring between the ages of five and ten, and rarely thereafter. In all prob-

ability there is no specific etiologic agent, and, like many pathologic processes in joints, may be regarded as a reaction that is induced by many different and distinct factors. Five theories of causation have been suggested.

1. *Trauma.*—Evidence of definite injury to the hip is present in many cases and was considered by Legg in his first report as the probable causative agent.

2. *Infection.*—A low-grade infectious process, which is probably acquired from a distant focus is thought by Freiberg to be a probable cause.

3. *Congenital Malformation.*—Jansen and Delitala have demonstrated malformation of the pelvis involving the acetabulum, and inducing an eccentric articulation. They believe that this unequal distribution of weight by repeated trauma produces characteristic changes in the epiphyseal disk.

4. *Nutritional.*—Calvé regards the condition as rachitic, due to impaired nutrition, although no evidence is usually present in other bones to support this theory.

5. *Syphilis.*—Lues has been suggested as a causative agent by Roberts, but the Wassermann reaction is usually negative and there is rarely other evidence of congenital syphilis.

Pathology.—As operative measures are rarely required during the active process and death occurs only from some intercurrent disorder, there is little known as to the pathology. Kidner found an abscess in the neck of the affected femur which upon culture showed the *Staphylococcus aureus*, and on microscopical examination a low-grade inflammatory process was found. Phemister, likewise, observed evidence of a low-grade inflammatory process. The roentgenogram shows the following characteristic evolutionary process. At the onset the head of the femur loses its normal globular shape and is slightly flattened, and there is also an apparent upward and outward displacement of the femoral disk. Legg has described two distinct varieties, the mushroom and the cap types. In the mushroom type the head of the femur is rounded and flattened, while in the cap type, the head though flattened is not spread out as in the mushroom type. Coincidently, there are mild destructive changes in the acetabulum, which may be due to an infectious process or mechanical irritation from the irregularly shaped head of the femur. The diameter of the neck is also increased, which makes it appear shorter than the neck of the normal side. After several months there is fragmentation of the epiphyseal disk, which may even partially disappear. The result is a broadening and flattening

of the head of the femur that may remain permanently. Ankylosis does not take place, though materially restricted motion with deformity may occur.

Symptoms.—There are no constitutional symptoms. A slight limp is the first symptom. At the onset, the limbs may be of equal length, but later the trochanter becomes prominent, and there may be from ½ to 1 inch shortening. Pain is usually mild and referred to the anterior aspect of the thigh or knee. There is slight muscular atrophy. Motion is limited in abduction and internal rotation, and also occasionally in extreme flexion. Not infrequently motion may be limited to some extent in other directions beside abduction and internal rotation and very rarely the symptoms may be markedly exaggerated, closely resembling an acute tuberculous invasion of the hip joint. Moderate

Fig. 104.—Coxa plana with progressive flattening and fragmentation of head and broadening of neck of femur.

adduction may develop as the process advances, but rarely is gross malformation observed. The evolution of the process requires about one year's time, and after subsidence good function may be reestablished.

Diagnosis.—The characteristic local and roentgenological manifestations are almost pathognomonic. Except in those rare instances of coxa plana with exaggerated symptoms, differentiation from tuberculosis can be made by clinical observation. In coxa plana motion is limited chiefly in abduction and internal rotation, whereas in tuberculosis of the hip, motion is limited in all directions and the other symptoms are exaggerated. In psoas contracture resulting from abscess about the origin of the psoas muscle, motion is limited chiefly in extension and the symptoms are usually referable to the spine and

not to the hip. Also, a psoas abscess may be palpated on the affected side above Poupart's ligament. In coxa vara, or epiphyseal separation, the age incidence is different, occurring about adolescence. The symptoms of the two conditions are quite similar. In coxa vara of rachitic origin, there is evidence of rickets elsewhere in the skeletal system.

Prognosis.—Good function may result in those receiving no treatment, but recovery with less impairment of function is accomplished when efficient measures are instituted. Rarely, in untreated cases there may be gross malposition or deformity. Later in life the irregular articulation may be conducive to arthritic changes, although often no further symptoms are experienced.

Treatment.—Recumbency with extension is advisable when the process is acute or when fixed adduction is present; traction should be continued until the symptoms abate and malposition is corrected. Abduction may also be secured by forcible manipulation, after which a plaster cast is applied with the limb abducted to 45 degrees and rotated inward. The cast is worn for three months and a Bradford abduction brace is then applied to permit walking. In from three to six months the first brace is exchanged for a Thomas caliper brace with a joint at the knee, permitting free motion, which is worn from three to six months or until the roentgenogram demonstrates that the process has subsided. Eradication of all infected foci is indicated, though such measures seemingly produce no beneficial effect upon the local process.

Heliotherapy and the mercury quartz light are thought to be beneficial, though no evidence as to a more rapid arrest of the process by such measures has been observed.

In the more exaggerated type there may be gross deformity with impairment of joint function, but there is usually a fair range of motion. When function is limited, operative measures are indicated, but these differ from surgical measures for tuberculosis in that, when advisable, the joint may be entered with impunity. In those with a practical range of motion with fixed flexion and adduction, the severance of contracting soft structures should be employed, after which the hip is maintained by fixation apparatus until all tendency toward occurrence of malposition has ceased, which is usually from three to six months. In those in whom contractures of the soft structures are associated with an incongruous joint, causing mechanical blocking or irritation, manifested by an expanded head with irregular osteocartilaginous outgrowths, the joint should be explored. The head of the femur is dislocated and the outgrowths are removed, the circumference

of the head made smaller, smooth, and even, care being taken not to remove any cartilage or bone or to injure the remains of the epiphysis which might decrease the length of the femur. The head is then replaced within the socket, the wound closed, and the limb placed in the most useful position and so retained by a plaster cast for eight weeks. At the end of this period, a Bradford abduction hip splint is applied and worn for about six months. Physiotherapy may be employed for the cultivation of active and passive motion.

Coxa Vara

Coxa vara is a term employed when the normal angle formed between the neck and shaft of the femur is decreased from any cause, and means a turning in of the hip joint, as varus indicates the turning in of the foot. The normal angle between the neck and the shaft is about 160 degrees in children, 140 degrees in adolescents, 130 in adults, and often as low as 120 in the aged. If the angle is below 115 degrees, the mechanics of the hip joint are naturally impaired. The term "coxa vara," while employed to designate the above-mentioned mechanical changes in relation between the neck and the shaft of the femur, is also used to define a clinical entity due to a separation of the upper femoral epiphysis. Coxa vara, or epiphyseal separation, occurs only during adolescence, between the ages of twelve and eighteen years, more often about fourteen or fifteen years, and is not possible after full growth has been attained when the epiphyses are obliterated by osseous fusion. Müller first established the relationship between the clinical syndrome and incurvation of the neck of the femur.

Etiology.—Hypopituitarism, or other endocrine imbalance, is a predisposing cause, as the process more often occurs in the effeminate type of fat boy with undeveloped genital organs. Coxa vara of adolescence also occurs in normal individuals. Boys are affected more frequently than girls in the proportion of about four to one. Latent rickets is also regarded as an etiologic factor. The distribution is usually unilateral, though both hips may be involved. Trauma is probably only an exciting agent in the neuter type, as bilateral coxa vara could not be so explained, unless it be accepted that excessive weight acting by the force of gravity on an area of decreased resistance is trauma. Trauma often causes partial separation, but usually no symptoms are manifested until there is displacement of the epiphysis, induced by weight-bearing, with material decrease in the angle between the neck and shaft of the femur. As in coxa plana, a low-grade infectious process is a possible causative agent, but so far sufficient evidence has not

been submitted to confirm this theory. It is quite probable that coxa vara is caused by the same pathologic process as coxa plana, but the former occurs at a more advanced age.

Pathology.—The pathology is demonstrated by the roentgenogram. There is definite separation of the epiphysis with an apparent degenerative and proliferative process. The head is displaced downward, or the neck upward, thus decreasing the angle between the head and the neck. The head may become broad, flat and irregular—the so-called mushroom head. The diameter of the neck is increased and usually bowed forward as the more powerful external rotator muscles, aided by the force of gravity, rotate the limb outward. In coxa vara, the head slips downward and away from the greater trochanter, thus

Fig. 105.—Coxa vara with downward displacement of head on neck of femur.

Fig. 106.—Same as Fig. 105, after correction by manipulation, showing normal relation of head and neck of femur.

lengthening the upper border of the neck and causing the epiphyseal line to approach the vertical plane. In coxa plana, as stated by Key, the direction of the epiphyseal line is changed to approach more nearly the horizontal. However, the upper femoral epiphysis is normally horizontal before the age of eleven and gradually assumes a vertical position as age advances, complete ossification of this epiphysis occurring usually in the fifteenth year. The cotyloid cavity is lengthened longitudinally and diminished transversely, taking the form of an ellipse. In a certain proportion of cases there are also chronic arthritic changes. The cartilaginous covering of the femoral head disappears from its lower part, and sometimes encroaches on the superior border

of the neck. Rarely the opposite forces of internal rotation may be more active when the neck is bowed backward.

According to Noble, the iliofemoral ligament produces the incurvation of the neck of the femur. When both attachments of the ligament are approximated by a movement upward of the great trochanter, hyperextension takes place, and the external rotators produce outward rotation of the entire leg. There is usually an elevation in the superior border of the neck by osseous reinforcement; the neck shows modification of structure, according to Wolf's law, with softening and atrophy of the superior part and reinforcement by compact bone in its lower part. According to Key, microscopical examination shows the epiphyseal line broadened and vascular. The cells have lost their orderly arrangement in columns and are scattered irregularly through the cartilage matrix. The bone and marrow of the head and neck are essentially normal. Islets of cartilage may be in the marrow in the vicinity of the epiphyseal line.

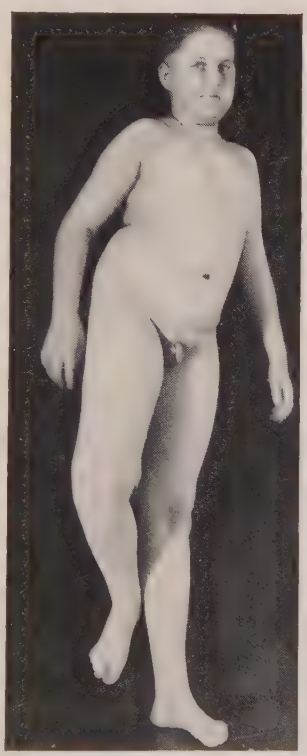


Fig. 107.—Coxa vara. Note adduction and outward rotation of thigh occurring in patient with Fröhlich's syndrome.

Symptoms.—There are no constitutional symptoms, except those of endocrine imbalance. In the early stage the local symptoms are similar to coxa plana. Pain is slight and is referred to the thigh or knee. Atrophy and muscular spasm are not pronounced, except in those in whom the deformity is not arrested by efficient treatment. Limitation of motion is mechanical and in the early stage is confined chiefly to abduction and internal rotation and, to some extent, flexion. In flexing the hip and knee, the hip is rotated outward so that the thigh approximates the lateral aspect of the body, rather than the abdomen, as occurs normally. Abduction is restricted by the approximation of the greater trochanter to the pelvis and the neck of the femur against the rim of the acetabulum. Internal rotation is blocked by impingement of the anteriorly bowed neck when the limb is rotated inward. On standing, the limb is held externally rotated so that the toes turn outward and the trochanter is prominent and above Nélaton's line. There is a slight

limp of shortening at the onset which is gradually increased. In those with bilateral coxa vara there is a peculiar waddle with out-toeing that is quite characteristic. If deformity is not prevented, there may be extreme adduction, as the neck bends to an acute angle, and motion may be completely blocked or there may be osseous ankylosis.

Diagnosis.—The diagnosis can be made by the local manifestations which are easily confirmed by the roentgenogram. Symptoms referable to the hip in the effeminate type of the fat boy are usually due to coxa vara. The age of occurrence is different from that of coxa plana, which occurs during the middle years of childhood. Differentiation from coxa plana may also be made by the roentgenogram; in coxa plana the epiphysis is displaced upward and in coxa vara downward. Motion is limited in all directions in tuberculosis of the hip, while in coxa vara, in the early stage, the restriction is chiefly in abduction and internal rotation. In tuberculosis, atrophy of the thigh and all symptoms are more acute and at the onset, the roentgenogram shows slight, if any, change. In coxa vara, the process is detected early by the roentgenogram and is more rapid. In psoas abscess, symptoms are usually referable to the spine and motion is restricted mainly in extension or hyperextension. In congenital dislocation, normal motion is increased in all directions. The absence of the head of the femur in the acetabulum can be detected on palpation and the limp is elastic with excursion of the trochanter upward as each step is taken.

Prognosis.—Impairment of function by limitation of internal rotation and abduction, and decrease in length from $\frac{1}{2}$ to 1 inch may result regardless of the efficiency of treatment. This is due to arrest in growth and displacement of the epiphysis. Rarely there may be no abnormality apparent after efficient treatment. However, more frequently there is some permanent impairment of function caused by limitation of internal rotation and slight decrease in length, but for all practical purposes the limb is normal.

Treatment.—If there is endocrine disturbance, the administration of specific glandular products is indicated, and in those of excessive weight dietetic measures are also employed. In a large percentage of those with separation of the upper femoral epiphysis, manual reduction may be accomplished under anesthesia by forcible abduction and internal rotation. A plaster cast is applied, maintaining the limb for two or three months in extreme abduction and internal rotation, after which a Bradford abduction hip brace which permits walking without weight-bearing upon tne neck of the femur, is worn until the roentgenogram demonstrates that the process is arrested. This requires

from four months to one year. After removal of the abduction hip splint a Thomas caliper brace is applied which partially removes weight from the neck of the femur. At the end of about one year apparatus is discarded, but clinical and roentgenological observations should be made frequently until all danger of recurrence has passed. In case of relapse the mechanical measures are resumed. The relation of the epiphyseal disk to the neck can be determined early by stereoscopic roentgenograms.

If there is an absence of endocrine disturbance, and the displacement can not be manually reduced, open reduction is required. No internal fixation is necessary, as the normal relations can be maintained by apparatus holding the leg in the abducted position. The after-treatment is the same as in those manually reduced. When there is a residual deformity of flexion and adduction of the hip, function may be improved, after the process has been arrested, by a subtrochanteric osteotomy. The limb is placed in abduction of about 45 degrees and internal rotation, and so maintained by a plaster cast until osseous union has occurred; the Bradford abduction brace is then employed for two or three months. A practically normal extremity may be the result if the deformity is moderate and in those in whom there is acute angulation, much improvement may be secured. When ankylosis is present, an arthroplasty may be contemplated after the deformity has been corrected.

Fig. 108.—Coxa valga.

Coxa Valga

Coxa valga is the reverse of coxa vara; the angle which the neck of the femur makes with the shaft is increased and the neck elongated. The condition, unlike coxa vara, is not caused by epiphysitis, but is due to lack of weight-bearing on the limb as occurs after amputation or in infantile paralysis. Coxa valga is not pathologic, but is merely the result of functional adaptation. There are no symptoms except the increase in the angle of the neck of the femur, as shown by the roentgenogram. The treatment consists of

measures to increase weight-bearing, which may require special apparatus.

Vertebral Osteochondritis

A process analogous to osteochondritis of the other bones occurs in the vertebrae during the period of growth. The terms "epiphysitis of the spine" and "osteochondritis of the vertebral body" have been suggested, because of the similarity of the affections to degenerative changes in the intra-articular and extra-articular epiphyses elsewhere. Buchman has called attention to the fact that the superior and inferior vertebral epiphyses do not appear until the age of eleven or twelve years, and states that the condition should not be called epiphysitis previous to the development of the secondary ossific centers. The age of incidence of osteochondritis of the central portion of the body is the first decade of life. Vertebral epiphysitis is rarely seen before eleven years of age unless there is a premature ossification of the epiphyses. The

Fig. 109.—Osteochondritis of spine with wedge-shaped compression of vertebrae.

Fig. 110.—Rounded kyphos in vertebral epiphysitis.

etiology of the two conditions is probably indentical and is doubtlessly similar to that of osteochondritis and epiphysitis in other bones. The symptoms and clinical course are also similar. The age of onset is the period of most rapid growth for the area of bone involved. The symptoms are moderate or slight pain, tenderness, muscular spasm, limitation of motion, and finally fixed deformity of the back. Kyphosis or scoliosis may develop depending upon the area of the spine involved and the secondary factors of stress and strain. The clinical signs are similar to those of tuberculosis of the spine, but are much milder. The roentgenogram in osteochondritis shows an irregularity of outline of the vertebra with a mottled, porous appearance throughout the affected area. Later the bone becomes more dense and sclerosed; the body is wedge-shaped, the intervertebral space is not diminished and may be increased in width in proportion to the flattening of the vertebrae. One or several adjacent vertebrae may be affected. In epiphysitis the roentgenological manifestations are confined to the upper and lower surfaces of the bodies of the vertebrae. The margins of the body become indistinct and the outline is irregular. The epiphyses are enlarged, frayed, and less dense than normal, lying separated from the parent bone by an interval of varying degree. The central portion of the body appears normal and the intervertebral space is cloudy, mottled, and irregular. In the later stages there is fragmentation and striation. The epiphyses appear as dense shadows, but they do not return to their normal size. The vertebral bodies are wedge-shaped and the superior and inferior borders present an irregular dense striated appearance.

Diagnosis and Treatment.—The diagnosis is made with more difficulty than in the other epiphyseal affections, but the condition will be confused mainly with tuberculosis of the spine and Kümmell's disease. The mildness of the symptoms, the roentgenological appearance and the tuberculin test in young children should be sufficient to differentiate it from tuberculosis. In Kümmell's disease there is usually a history of trauma followed by a period of quiescence before the symptoms are apparent. The treatment is always conservative; rest and immobilization of the spine by apparatus are required until the symptoms subside and the roentgenogram demonstrates restoration of the affected portion of the spine to normal. Operative measures to induce spinal fusion are unnecessary unless deformity is impending.

Generalized Epiphysitis

Generalized epiphysitis may be present in undernourished individuals in late childhood. Many epiphyses may show irritation and proliferation with slight pain and tenderness. The treatment is cod liver oil, artificial and natural heliotherapy, together with local measures applicable to the epiphyses affected.

ENDOCRINE DISTURBANCES

Abnormalities of the endocrine glands, such as the thyroid and pituitary, may cause gross pathologic changes in bones and joints. The most common is possibly due to deficiency of the pituitary gland and is manifested in the joints as an arthritis which may involve practically all the joints. Acromegaly and gigantism are affections of this type. The diagnosis of endocrine imbalance is usually evident by the well-known stigmata of such conditions. However, the condition is not uncommon in milder degree in many apparently normal individuals, and there may be a close resemblance to a low-grade affection of the joints, especially ostearthritis. The administration of glandular products is indicated, though organotherapy is of doubtful permanent value.

HEMOPHILIC AFFECTIONS

A congenital defect or rarely toxins or sepsis may cause constitutional abnormalities with alteration of the coagulating elements in the blood. Hemophilia is the affection most commonly observed with joint manifestations.

Symptoms.—Repeated reactions in joints following slight injuries in young athletes are often due to a decrease in the coagulation time of the blood. There is rapid distention of the joint with blood, and later organization of the blood clot causes adhesions. The temperature may be slightly elevated or high, and may persist for several days simulating an acute pyogenic infection. Recurrent attacks are common and may induce deformity and malposition. A history of repeated and continuous bleeding from slight injuries is usually obtainable and should suggest the diagnosis.

Diagnosis and Treatment.—The diagnosis is verified by determining the coagulating properties of the blood. Normal coagulation time is from five to seven minutes. In hemophilia the clotting time may be delayed from twenty or thirty minutes up to an hour and a half or two hours. The determination of the bleeding time and the prothrombin time, and an estimation of the number of blood platelets are valuable in differentiating hemophilia and purpura. The

bleeding time in hemophilia is usually normal, and in purpura hemorrhagica is prolonged. The coagulation time and prothrombin time are normal in purpura hemorrhagica and the number of blood platelets is diminished, while in hemophilia the platelets are often normal or sometimes increased. The total white and differential counts are normal in hemophilia, while in pyogenic infections the leukocyte count is increased. The treatment during the active stage is by blood transfusions and serums which are of value, but which are of doubtful permanent benefit. Total abstinence from athletic games should be rigidly observed and all trauma avoided when possible. Operative procedures are obviously contraindicated.

NEOPLASTIC JOINT AFFECTIONS

Bone tumors are discussed in Chapter XIII, but neoplasms may arise primarily within a joint, or may invade the joint from without and mechanically interfere with joint function. The pathology of such tumors is the same as that of tumors arising in other tissues and organs of mesodermic origin. The symptoms and local manifestations vary with the type of neoplasm present. They may be classified according to clinical manifestations as benign or malignant.

Benign Intra-articular Tumor.—The primary intra-articular neoplasms of joints are lipoma, fibroma, benign endothelioma, chondroma or enchondroma, xanthoma, angioma, osteoma, and cysts. The symptoms induced by intra-articular tumors are entirely mechanical. If small, symptoms of internal derangement are present with fluid and other evidences of an arthritis caused by constant irritation. Large growths encroach upon the joint cavity and destructive changes may occur from pressure. The joint on inspection and palpation will show a change in contour commensurate with the shape and size of the tumor, or if it is small, the tumor can only be demonstrated by palpation.

Lipomas, as the name implies, are composed of fat, and may be lobulated or encapsulated as an oval or spindle-shaped pedunculated mass. Evidence of recent or old hemorrhage caused by impingement between the articular surfaces is frequently observed within the tumor. Fibromas are hard, resistant tumors of dense fibrous tissue and are encapsulated, pedunculated, and attached to the synovia, or may apparently develop from the tendons or the capsule. Chondromas are a type of loose body discussed in the section on internal derangements of joints. Xanthomas are pigmented giant-cell tumors which are encapsulated and may occupy a large portion of the joint space. Endotheliomas may occupy the entire joint, which appears to be dis-

tended by fluid, and on palpation may give the tactile sense of fluctuation, though on aspiration no fluid can be withdrawn. Angiomas are tumors composed of a diffuse mass of blood vessels held together by loose connective tissue. They are of rare occurrence and are usually benign. Cysts of the cartilage are not in reality, tumors, but present the same clinical phenomena. They are derived from the semilunar cartilages, more frequently from the external cartilage, and are described in the section on Internal Derangements.

The presence of lipoma and cysts may often be determined by palpation, osteomas and chondromas by the roentgenogram. The diagnosis of angioma, xanthoma, and benign endothelioma can only be made by excision and biopsy. The prognosis is good if the tumors are removed before there has been irreparable damage with organization of intra-articular structures. Operative procedures consisting of arthrotomy and complete excision of the tumor are necessary. Rarely neoplasms, such as endotheliomas, may occupy the entire joint and require complete synovectomy.

Recurrent Tumors.—Recurrent neoplasms are those which recur after apparent removal, but do not metastasize, and it is possible that such recurrence is largely due to incomplete removal. Those of most frequent occurrence in and about joints are enchondroma and fibrosarcoma. The treatment is excision with complete resection of the surrounding synovia or other structures from which tumors may originate.

Malignant Tumors.—Primary malignant tumors are of such rare occurrence in joints as to be negligible, but the joint is often invaded from without by a neoplasm arising in adjacent bone, or a joint may be invaded by metastasis from a remote sarcoma or carcinoma. Malignant tumors arising in bone are discussed in Chapter XIII.

BIBLIOGRAPHY

Buchman, Joseph: Vertebral Epiphysitis, Jour. Bone and Joint Surg., 7:814, 1925.

Ibid.: Osteochondritis of the Vertebral Body, 9:55, 1927.

Calvé, Jacques: Sur une forme particulère de pseudo-coxalgia greffée sur des déformations caracteristique de l'extrémité supérieure du fémur, Rev. de Chir., 30:54, 1910.

Ibid.: A Localized Affection of the Spine, Jour. Bone and Joint Surg., 7:41, 1925.

Campbell, Willis C.: Localized Osteospondylitis, Jour. Amer. Med. Assoc., 67:572, 1916.

Ibid.: Infraction of the Head of the Second and Third Metatarsal Bones; Report of Cases, Amer. Jour. Orthop. Surg., 15:721, 1917.

Ibid.: An Analysis of Bone and Joint Lesions of Known Syphilitic Origin, Radiology, 5:122, 1925.

Delitala, F.: Contribution for Study of a Typical Disease of the Upper End of the Femur (Perthes' Disease), Amer. Jour. Orthop. Surg., 12:555, 1915.

Freiberg, A. H.: Infraction of the Second Metatarsal Bone, Surg., Gynec. and Obst., 19:191, 1914.

Ibid.: The Evolution of Osteochondritis Deformans Juvenilis, Jour. Amer. Med. Assoc., 67:658, 1916.

Hadjopoulos, L. G., and Burbank, Reginald: A Preliminary Study Bearing on the Specific Causative Factors of Multiple Infective Arthritis, Jour. Bone and Joint Surg., 9:278, 1927.

Jansen, Murk: Flattened Hip Socket and Its Sequela, Jour. Bone and Joint Surg., 5:528, 1923.

Key, J. A.: Epiphyseal Coxa Vara or Displacement of the Capital Epiphysis of the Femur in Adolescence, Jour. Bone and Joint Surg., 24:53, 1926.

Kidner, Frederick C.: Causes and Treatment of Perthes' Disease, Amer. Jour. Orthop. Surg., 14:339, 1916.

Köhler, A.: Typical Disease of the Second Metatarsal Phalangeal Joint, Amer. Jour. Roentgenol., 10:705, 1923.

Ibid.: Ueber eine häufige bisher anscheinend unbekannte Erkrankung einzelner kindlicher Knocken, München. med. Wchnschr., 55:1923, No. 37, 1908.

Legg, A. T.: An Obscure Affection of the Hip Joint, Boston Med. and Surg. Jour., 162: 202, 1910.

Muller, E.: Ueber die Verbiegung des Schenkelhalses im Wachtumsalter, Beitr. z. Klin. Chir., 4: 137, 1888–89.

Nichols, E. H., and Richardson, F. L.: Arthritis Deformans, J. M. Res., 21:149, 1909.

Noble, T. P.: Adolescent Coxa Vara, Ann. Surg., 80:773, 1924.

Osgood, R. B.: Lesions of the Tibial Tubercle Occurring During Adolescence, Boston Med. and Surg. Jour., 148:114, 1903.

Perthes: Ueber Arthritis Deformans Juvenilis, Deutsch. Ztschr. f. Chir., 107:111, 1910.

Phemister, D. B.: Operation for Epiphysitis of the Head of the Femur (Perthes' Disease), Arch. Surg., 2:221, 1921.

Roberts, Percy Willard: Congenital Syphilis as a Factor in Joint Disease, Amer. Jour. Surg., 37: 102, 1923.

Schlatter, C.: Verletzungen des schnabel-formigen Fortsatzes oberen Tibia-epiphyse, Beitr. z. klin. Chir., 38:874, 1903.

Young, A. G., and Youmans, J. B.: Use of Iodoxy-benzoic Acid in the Treatment of Infectious Arthritis, Jour. Amer. Med. Assoc., 87:746, 1926.

CHAPTER VI

LOW-GRADE AFFECTIONS OF JOINTS (Continued)

TUBERCULOSIS OF JOINTS

Tuberculosis is a constitutional disease, affecting the entire organism, and, consequently, when a joint is invaded, must not be regarded as a purely local problem. The bacillus of tuberculosis is the well-known etiologic factor. There are several types of the tubercle bacillus, but only two types, the human and the bovine, commonly cause infection in the human body. The infection, as in other joint affections, is derived through the blood stream from a distant focus, usually the bronchial nodes or possibly the intestinal tract, from in-

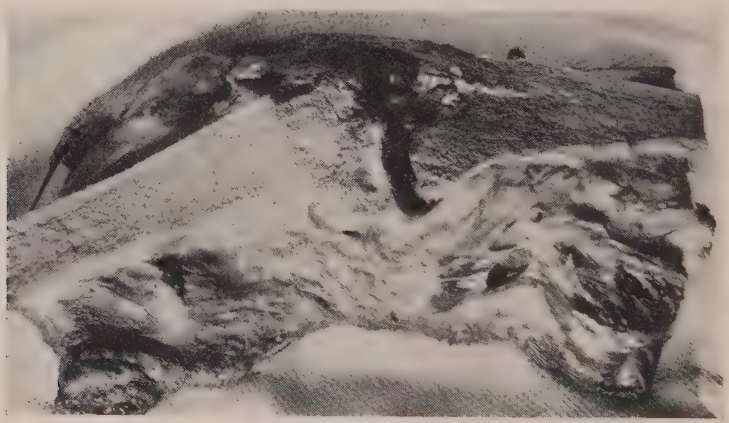


Fig. 111.—Cross section of knee showing tuberculosis with destruction of bone beneath articular cartilage on tibia and of articular surface of femur.

fected milk. The bovine type of infection, as pointed out by Fraser, is more prevalent in children than in adults. According to Cobbett, the incidence of the bovine type in very young infants constituted nearly one third of the total, while, considering all ages together, the incidence of the bovine type amounts to only one fifth of the total number of cases. Milk is the chief article of diet of the young child, and its contamination by the bovine tubercle bacillus naturally is followed by tuberculosis of the lymphatic nodes, cervical and mesenteric, and from this focus the bacilli are readily distributed to the

bones and joints. The human tubercle bacillus commonly gains entrance to the body by inhalation and finds it way to the bronchial lymph nodes. This is probably the more usual mode of entrance in the adult. The laboratory differentiation of the human and bovine types from the clinical and therapeutical standpoint, however, is unimportant, as the value of the information obtained is not commensurate with the time and labor involved. Besides the infecting organism, two other factors should be mentioned: first, the predisposition of the patient, and, second, the local conditions that favor the implantation and growth of the bacillus. Hereditary transmission can almost

Fig. 112.—Specimen from tuberculous knee showing typical tubercle with giant cell.

be excluded, but direct infection from association with some tuberculous member of the family is frequent. Mild trauma is an accepted predisposing cause, while severe trauma, as extensive fractures or crushing of the joint surfaces, is rarely, if ever, followed by tuberculosis. Tuberculosis of the joints begins more often between the ages of three and five, but is undoubtedly more common in adults than is generally known, as many cases of chronic arthritis continue until death ensues from other cause without a correct diagnosis being made. The spine is affected more often than any other part, next in frequency being, respectively, the hip, knee, and ankle, while the joints of the upper extremity are less often invaded.

Pathology.—The histopathology of tuberculosis in a joint is the same as a tuberculous process elsewhere in the body. The reaction in the tissues following deposition of the tubercle bacilli consists of a

proliferation of the cells lying in direct contact with the bacteria and results in the formation of a tubercle. These formations vary in size, depending upon the virulence of the offending organism and the resistance of the patient. In the early stage there is an accumulation of endothelial leukocytes and surrounding this an area of lymphocytes. Later, the endothelial leukocytes in the center of the tubercle coalesce and form a giant cell. The microscopical examination at this stage reveals a giant cell of the foreign body type, surrounded by a zone of amorphous granular material. Encircling this, and encroaching upon it, is another zone composed of endothelial leukocytes, many of which show a radial arrangement of their nuclei. Finally, an invasion by lymphocytes, polymorphonuclear leukocytes, and fibroblasts completes the picture. As the lesion becomes older, the fibroblasts are found nearer the center of the tubercle. The surrounding tissue is usually infiltrated by lymphocytes and endothelial leukocytes, which are attracted in such large numbers that occlusion of blood vessels occurs, resulting in necrosis. The toxins which are elaborated by the bacilli may also play a part in producing disintegration and caseation. The bacilli multiply and escape forming new tubercles about the original focus, which coalesce as the area of the disease enlarges.

Clinically, primary tuberculosis of the synovial membrane is occasionally observed, but the origin of the process within the joint is doubtful. The pathologic process usually begins in the bone, just external to the epiphysis, in the vascular area known as the metaphysis. There is a gradual atrophic and destructive process which invades the joint from without, the articular surfaces being undermined; consequently, a long period of time may elapse before the incrusting cartilage is affected. Coincidently with invasion of the bone, there is a sympathetic arthritis, as the process is in such close proximity to the joint. After the joint is invaded, there is a gradual proliferation of the synovia, hypertrophy of the villi, formation of granulation tissue in profusion, erosion of the articular surface, and often a change in relation, with malposition, subluxation or complete dislocation. While the existence of synovial tuberculosis is questionable, the clinical manifestations may be confined to the synovia as shown by a persistent distention of the capsule with fluid, redundant synovia, granulation tissue, and increase in thickness with formation of lobulated masses which can be detected upon palpation.

Cold abscesses are formed from caseation and necrosis; they follow the line of least resistance and appear beneath the skin as fluctuating masses, and as the abscess approaches the surface there is often secondary

infection by pyogenic organisms with the usual manifestations of sepsis. As the evolutionary process subsides, areas of tuberculous material are usually encapsulated within the joint by scar tissue, and may remain as latent and potentially active foci. Also, there is a proliferation of new bone in the affected area and the structure is more dense than normal.

Symptoms.—Local manifestations are more definite in children than in adults. The onset is gradual and insidious; joint tuberculosis is usually a monarticular affection. Pain is referred to a more distant point in the extremity when the disease is in the proximal joints, as the hip and shoulder, and in the peripheral joints, pain is local. Swelling is more apparent in the peripheral joints. Muscular atrophy occurs earlier and is more rapid than in other joint affections. Muscular spasm, or rigidity, is the chief characteristic manifestation. Local heat is usually increased. Malposition or deformity occurs unless prevented by mechanical measures. The muscular spasm limiting joint motion is less pronounced in adults and years may elapse before there is any material impairment of function. This is due to the fact that the bones of adults are harder, more dense, and not easily invaded as the bones of children. Constitutional symptoms are more apparent in children than in adults. At the onset the patient is usually well nourished, and there may be no debility until the symptoms become acute, with excessive pain and loss of sleep. Debility, or excessive loss of weight, is rarely present until the late stage or as the result of some complication such as secondary infection. The temperature at the onset is usually moderately elevated when there is involvement of the proximal joints, and to a greater degree when the distal and superficial joints are involved. In tuberculosis of the hip or spine, the evening temperature seldom exceeds 99 to 100 F.; in the distal joints, such as the knee, ankle, and elbow, the temperature is usually elevated to 101 or 102 F. In adults, fever is much lower than in children and in the adult patient the disease may continue indefinitely without elevation of temperature unless complicated by secondary infection. Abscesses, when deep, may be evidenced by a slight increase in temperature and may cause symptoms by mechanical pressure according to their location.

The most frequent complications are tuberculous abscess, pulmonary tuberculosis, tuberculous meningitis, and secondary infection with pyogenic organisms. Secondary infection is the most common late complication, being the cause of high temperature, night-sweats, excessive loss of weight, and often death by the synergetic action of

pyogenic bacteria and the bacillus tuberculosis. Amyloid degeneration of the viscera is a sequence of prolonged sepsis and is manifested by enlargement of the liver, spleen, and other internal organs. Tuberculosis of the lungs is more frequently a complication in adults than in children. Tuberculous meningitis is more frequent in children and rarely, if ever, occurs until there has been definite osseous destruction. Persistent nausea in any child with a tuberculous joint is an ominous sign, for when present other clinical symptoms of meningitis may soon appear.

Diagnosis.—The diagnosis can often, but not always be made by the symptoms and physical examination. The chief symptoms are pain, disability, limp, swelling, stiffness, and night-cries. The chief physical findings are swelling of the joint, with or without apparent increase of the synovial fluid, muscular atrophy on either side of the joint, increased local temperature and daily elevation of the general body temperature. There are no abnormal changes of diagnostic value in the blood, except that a high cell count usually indicates a secondary pyogenic infection. The tuberculin test is of more value in young children and is of greater significance when negative than when positive, as a large percentage of apparently normal persons give a positive reaction. The subcutaneous test is dangerous and should be used with extreme caution, while the von Pirquet skin reaction is safe and may be routinely employed. The joint fluid may be aspirated and submitted to the laboratory for examination. Injection of the aspirated material into guinea-pigs may also be made; at the end of six weeks the guinea-pig is killed and an autopsy made to reveal any evidence of tuberculosis. This test is seldom of value in the early stage, as the organism is rarely present in the fluid until destruction begins.

Biopsy is becoming more popular as a diagnostic measure and may be employed with impunity in all superficial joints, such as the knee and ankle, but in the light of our present knowledge, is certainly not feasible in such locations as the hip and spine. Obviously, great care should be taken to prevent secondary infection when employing this method, the technic of which is as follows: an incision is made through the most accessible route and of sufficient length to permit inspection of the joint as much information may be obtained in this way. A section is taken from proliferating tissue of the synovia, the capsule of the joint and granulation tissue on the joint surface or internal ligaments. The bone is not excised unless eroded, and when the process is so advanced as to show such extensive destruction, biopsy is not indicated as the diagnosis is evident clinically and by the roentgeno-

gram. The specimen removed is submitted to the pathologist for examination.

Even after microscopical examination the diagnosis is at times difficult and can be made only by a proficient and experienced pathologist with special training in bone and joint pathology. The guinea-pig test is also accurate only in proportion to the proficiency of the examining pathologist. After more experience both on the part of the surgeon in selecting the tissue to be examined and the pathologist in making the microscopical examination, the technic will become standardized and the results of such examinations will be of much greater value.

Roentgenoscopy.—The roentgenogram is of slight diagnostic value until there has been definite invasion of the bone, which may require many months. The first signs are paleness of the osseous structure as compared with the opposite joint and distention of the capsule of the joint. The gross manifestations of the evolution of the process are as follows: the process begins external to the joint, as is evident by an invasion of the epiphyses. Destructive changes are thus first observed beneath the articular surface which is undermined from without. Erosion of the surface is observed only after extensive invasion of the joint. With advancement of the process all parts of the joint will be destroyed until actual dislocation and gross loss of continuity may result. As the process subsides, there is a gradual condensation of bone in the area involved by the active process; surrounding this area there is a gradual restoration of the bone to the normal osseous structure. After the process has entirely subsided, there will be an increase in density as compared to normal bone, but the contrast is never so marked as in joints affected by pyogenic organisms. In those complicated by secondary pyogenic infection there is evidence of characteristic osseous hypertrophy from pyogenic infection combined with evidence of tuberculosis. The evolution of the process requires from one to three years, depending upon the joint involved and the virulence of the infection.

Differential Diagnosis.—Acute infectious arthritis in the subacute and residual stage is often confused with tuberculosis, but the history of the sudden onset, subsequent clinical course, and roentgenogram makes differentiation of the conditions possible. Syphilis can be diagnosed by the clinical symptoms, Wassermann test, and the roentgenogram. Low-grade epiphysitis, as coxa plana, runs a milder course and gives an entirely different visualization by the roentgenogram. In adults discrimination from other low-grade affections of joints, as infectious and subacute traumatic arthritis, may be more difficult, but

a detailed history together with the roentgenogram will usually establish the diagnosis.

Prognosis.—The prognosis for recovery with a practical degree of function preserved is unfavorable, and is only possible theoretically in those in whom the process may be arrested and encapsulated before the joint is invaded. When perfect results with restoration of a functional range of motion are observed, there has usually been an error in diagnosis, for tuberculosis once impregnated within the organism to such an extent as to manifest active symptoms is an evolutionary process that runs an indefinite course with destruction. The length of time required for such evolution varies in different joints. In conservative, as well as in operative treatment, observation is required for a period of at least three years. The only definite promise to be made as to the efficiency of local treatment is that deformity can be prevented or restricted to a minimum degree, and that the process will probably be arrested. In those receiving no treatment, or inefficient treatment, the course is more prolonged and indefinite, resulting in deformity and permanent disability. In adults, early operative measures for the purpose of fusing or immobilizing internally the affected joint will often arrest the local process. In children, there exists at present a difference of opinion as to the advisability of fusion; however, the preliminary reports are most encouraging, but sufficient time has not elapsed to reach definite conclusions.

Uncontaminated tuberculosis is rarely fatal unless there is invasion of a vital center as the cerebrospinal system. Death is more frequently due to secondary infection or other complications. The prognosis for life is better in children than in adults. The mortality is greater in involvement of the spine and hip joint and less in the upper than in the lower extremities. The results can best be expressed as arrested instead of cured, since dormant or latent foci may remain indefinitely regardless of the treatment employed. When abscesses are uncomplicated by secondary pyogenic infection, the prognosis is very slightly affected. With secondary pyogenic infection, the process is much more prolonged and the prospect of recovery materially reduced. Amyloid degeneration as a result of continued sepsis is usually fatal. Pulmonary tuberculosis, when associated, lessens the chances of recovery, but runs a milder course than when tuberculosis of the lungs occurs independently. Tuberculous meningitis is an infrequent but fatal complication.

Treatment.—The treatment of tuberculosis is local and constitutional, but the two methods can not be disassociated except for con-

venience in discussion. Routine measures consisting of fresh air, sunshine, and special diets, should be employed, a description of which can be obtained from special works on this subject. Heliotherapy has such a definite action on tuberculous processes that a detailed description of the technic of application is given.

Heliotherapy is the scientific application of the sun's rays in the treatment of disease. The beneficial effects of the sun's rays upon disease processes have been known since ancient times, but the procedure was first systematized and placed upon a scientific basis by Rollier, of Leysin, Switzerland. The rationale of the treatment is based upon the fact that the constant exposure of the body to the sunlight induces pigmentation of the skin, stimulates the physiologic

Fig. 113.—Heliotherapy at Crippled Children's Hospital, Memphis, Tenn.

functions of the skin, restores the natural tone of the muscles and causes an increase in density and dimension of the osseous structure. The sun treatment also promotes greater respiratory activity which improves the heart action and the general circulation. The metabolism is increased, the appetite is improved and the digestive functions are more normal. In addition, heliotherapy has a favorable action on the internal secretions by stimulating the endocrine glands.

Rollier regards the ultraviolet or actinic rays as the curative agent and calls attention to the fact that all parts of the spectrum (red, orange, yellow, green, blue, indigo, and violet, and the invisible spectra ultra-red and ultraviolet) are more intense at high altitudes, and that seasonal variations in the width of the spectrum are not so marked as in low lands. Such variations, he thinks, are due to the formation

of ammonia and nitrous compounds in the atmosphere from electrical phenomena, especially in the warmer months. The invisible spectra are contracted and this descreases the effects of the solar treatment in summer, while in winter there are few sunny days in the low countries and the cold damp atmosphere, with excessive wind currents, does not permit general exposure. On the other hand, at high altitudes there is less seasonal variation in the spectrum, more sunny days, and the air is pure, still, and dry, permitting almost continuous insolation. Other authorities have demonstrated that equally satisfactory results can be obtained at any level, and in many proportions of America heliotherapy can be given for at least nine months of the year. Heliotherapy may be administered either generally or locally, but only general heliotherapy, or exposure of the entire body will be considered in its application to the treatment of joint tuberculosis. Routine heliotherapy can be given to better advantage in institutions especially equipped for the purpose, but if this is not possible, instructions for several weeks in an institution will be of material advantage before treatment is begun at home, which can then be carried out very effectively.

Technic of Heliotherapy.—All clothing is removed from the patient and a simple T-strap applied to cover the genitals. Amber eye-glasses or goggles are worn to protect the eyes from the glaring light. A sunbonnet or broad-brimmed hat protects the head from the heat of the sun. In robust individuals, if the temperature is above 75 F., the entire body may be exposed for five minutes every two hours. The time is gradually increased until eight hours per day is reached. If the sun is intensely hot, the exposure should be started as early as possible in the morning and should be resumed in the later afternoon, omitting the midday hours. In cloudy weather exposure is not so effective but should be continued. In debilitated patients, and when the weather is cool, exposures for three minutes are made every two hours on the first day, the feet and the lower 4 inches of the legs are uncovered; on the second day, a new area of 4 inches is exposed in the same manner, while the first area is exposed for ten minutes every two hours. The entire body is thus exposed and gradually acquires tolerance to the sun and air. As the reaction of individuals differs, no arbitrary rule can be made as to maximum dosage of insolation; some will improve on ten hours while others can stand only six. Heliotherapy must not be indiscriminately administered or much harm may accrue, and the dosage must be regulated to each individual. If headache, weakness or malaise is present, the time of exposure should be decreased or the

treatments discontinued temporarily, to be resumed later and more gradually. Especial care must be taken not to burn or blister the skin, for if this occurs the treatment will not only be delayed but the patient discouraged and unnecessarily annoyed.

Improvement is synchronous with pigmentation which is an index of efficient treatment. Rosselet, a physicist, suggests that possibly pigmentation of the skin transforms the long light waves into shorter waves of deeper penetration, thereby reaching the superficial blood vessels. Response to treatment is not so satisfactory in those who do not pigment or freckle, as blondes, particularly red blondes. Brunettes will become a mahogany brown. The blackest negroes become a shade blacker and there is slight danger of sunburn. The influence of heliotherapy on the pathologic process is demonstrated by the roentgenogram. About the time pigmentation is established, there is increased activity, as denoted by breaking down the osseous structure. Later absorption of necrosed areas will be observed, the affected bone becomes more opaque and by the end of six or eight months is often more dense than normal with beginning fusion of the joint. The inflammatory exudate surrounding the affected area becomes irregular and gradually diminishes in circumference, or at times undergoes calcification; after a few months' exposure rapid destruction of the joint surfaces is often observed. This rapid evolution is probably due to the removal of devitalized tissue by natural forces, stimulated by the tonic action of the sun's rays, and might easily be mistaken for an acute exacerbation. This hastening of the evolutionary process is also evident in those with secondary infection and draining sinuses, the discharge of which is markedly increased after insolation, but later subsides and becomes less purulent and more serous as healing progresses.

Undoubtedly, fresh air has a beneficial effect, but the relative improvement is much greater in those treated by heliotherapy than in those treated by fresh air without removal of the clothing. The results are also more lasting with less danger of recurrence than after any other method. The length of time required to secure satisfactory results varies, but excellent results have been obtained after so short a time as five months. In all tuberculous affections overtreatment is advisable. In every case at least two seasons of nine months' insolation should be given, but in the majority, three years of continous treatment. When the finances of the patient permit, there should be a close pursuit of the sun for the entire twelve months' of the year, which can be acquired by moving to warmer climates, as Florida, Southern California, or Texas during the winter season. The necessity of a

change of climate is often more essential in bone than in pulmonary tuberculosis, as many clinicians believe that climate has no influence on the latter condition.

Actinotherapy or artificial heliotherapy is the treatment of disease by rays of light, especially actinic or chemic light, and may be used during the months in which direct exposure to the sun's rays is not practicable, although the same beneficial result is not to be expected. There are several types of mercury quartz lamps on the market specially constructed to give off the actinic or ultraviolet ray, which is probably the curative agent of the sun's rays. All clothing is removed from the patient. Amber eye-glasses or goggles are worn to protect the eyes from the glaring light. The patient is placed in a recumbent position and subjected for three minutes during the first treatment to the action of the rays of the lamp, which is suspended 12 inches above the patient. If the patient can be turned, the back is also exposed to the light for three minutes. The time of treatment is increased one to three minutes daily, as the skin acquires tolerance to the rays, until one hour per day is reached, or pigmentation is established. As in heliotherapy, improvement is synchronous with pigmentation and response to treatment is not so satisfactory in those who do not pigment or freckle. The dosage must be regulated to each individual, the maximum for any patient after tolerance is acquired being six hours per day.

Marine treatment is the routine bathing of the tuberculous patient in the sea, and is of tonic value, especially when combined with heliotherapy.

Orthopedic treatment may be divided for convenience of description into nonoperative and operative.

Nonoperative Treatment.—The nonoperative orthopedic measures consist of the prevention of deformity and rest of the affected parts until the process has been arrested by natural forces. This is accomplished by the employment of apparatus constructed to meet the mechanical requirements of each joint and to maintain the most useful position for future use. These measures must invariably be strictly and continuously employed in conjunction with any and all forms of treatment for tuberculosis of joints, whether constitutional or operative. In those observed in the early stage, or even in a later stage before the deformity has become fixed by strong adhesions, malposition can often be corrected by special apparatus which, by well directed force, often combined with traction, very gradually and slowly aligns the affected part in the most useful position. Care must be exercised at

all times not to induce force too rapidly; otherwise, there may be a relighting of the local process with metastasis, causing disastrous complications such as tuberculous meningitis.

Operative Treatment.—Tuberculous abscess should be treated conservatively unless rupture is inevitable or life is endangered by mechanical pressure on vital parts. Heliotherapy is the most efficient measure and should be routinely employed. The local treatment consists of aspiration when fluctuation is present after which continuous compression is made by bandages. When secondary infection by pyogenic organisms is a complication, evidenced by constitutional symptoms of high temperature and other indications of sepsis, incision and drainage should be carried out along the same principles as the treatment of all pyogenic abscesses. Efficient orthopedic treatment is also required, depending upon the location. The injection of various antiseptics into the abscess is routinely employed by many surgeons but is of doubtful efficacy. Unless some definite advantage is to be gained indiscriminate operations may have a deleterious effect. Sinuses may be defined by injection of opaque substances, such as bismuth, after which excision or drainage may be instituted. In a large percentage of cases, conservative treatment is the method of choice.

Brisement forcé, or forcible movement under anesthesia, occupies a relatively unimportant place in the treatment of tuberculous joint and must at all times be employed with great caution. This procedure is exceedingly dangerous in the hip as it usually causes metastasis and meningitis. Brisement forcé may be employed when gross dislocations of certain joints can not be correctly reduced by apparatus; for example, the procedure is permissible in the knee when there is gross subluxation of the tibia.

Excision is rarely feasible, even though the disease focus is small, unless it is possible to excise the entire bone, as, for example, the astragalus. Resection of the joint for the purpose of eradication of the disease process is obsolete in both children and adults, but is especially contraindicated in children, not only on account of affecting growth by injury or removal of the epiphyses, but because the process is very rarely arrested. In adults, excision is indicated in the elbow, but seldom, if ever, in any other joint. Definite sequestra when demonstrated by the roentgenogram may at times be removed with beneficial results, and sinuses may be excised or properly drained.

Arthrodesis.—The operation of arthrodesis is employed to induce fusion or ankylosis of the affected joint. Fusion of all tuberculous joints is now advocated by some writers in both adults and children.

The principles of the procedures for fusion are practically the same as the orthopedic measures previously employed—to enforce rest with fixation and to prevent deformity until nature encapsulates the pathologic process. By means of fusion a better fixation is secured and it has been proved beyond all doubt by clinical experience that the arrest of the process is more complete and lasting when osseous ankylosis results from any form of treatment. However, emphasis can not be too strongly made that conservative treatment, as mechanical fixation and all measures tending to elevate the stamina and the natural resistance of the patient must be constantly and rigidly employed, in both adults and children, and that fusion is only a valuable adjunct and must not be viewed in the light of a curative agent. In fact, the chances of a permanent recovery are much greater when such measures as heliotherapy, proper diet, and fixation by orthopedic apparatus and operative measures are judiciously combined.

Hibbs is an ardent advocate of fusion in all tuberculous joints regardless of age. He believes that the treatment of tuberculous joints in the past has been unsuccessful by the routine mechanical measures employed, and urges a radical departure from the former recognized treatment. Sufficient time has not elapsed to reach definite conclusions, though the preponderance of evidence is in favor of fusion. The author does not regard the prognosis with conservative measures so gloomy as the conclusions of Hibbs would indicate. Cases are frequently observed in which the process has apparently been arrested for many years, and in rare instances with good function.

Indications for Arthrodesis.—The indications for fusion operations vary in different joints, but the present status as to the indications in general is as follows:

1. In practically all adults the treatment by fusion is the procedure of choice. In adults, the incrusting cartilage is thin and bone may be reached a short distance from the surface; whereas, in young children there is a preponderance of cartilage in the articular extremities comprising the joints; hence, osseous fusion is not so easily secured. All tuberculous joints in those above the age of fourteen should be fused as early as possible, with the exception of the elbow in which satisfactory results may be obtained by excision.

2. In young children, between the ages of three and five, when tuberculous arthritis is more prevalent, the induction of intra-articular fusion is difficult as has been proved by such measures in anterior poliomyelitis. If extra-articular fusion can be secured, invasion of

the joint, with the possibility of relighting an active infection or inducing a secondary infection is avoided.

3. The induction of osseous fusion is influenced by the stage of the existing pathologic process. The early stage, before there is extensive destruction or osteoporosis, or the late residual stage after the osseous structure has returned to normal, is the most favorable time to induce fusion. In the stage of active osseous destruction, with acute symptoms, often complicated by abscess, the likelihood of inducing bony union is less, and there is also the possibility of converting a closed tuberculous process into an open one with secondary infection.

4. Fusion operation may be employed in conjunction with extra-articular osteotomy for the purpose of correcting deformity when present, as the intra-articular correction of malposition may require surgery so extensive as to instigate an active tuberculous process.

5. Fusion in the presence of an active pyogenic secondary infection should be undertaken with great caution. The probability of relighting an actively virulent process, even though it is apparently arrested, is much greater in those in whom such a secondary infection has occurred.

Technic of Arthrodesis.—The technic differs with the anatomy of the individual joint, and may be classified as: (*a*) Intra-articular, (*b*) intra-articular and extra-articular, (*c*) extra-articular.

Intra-articular Technic.—The intra-articular procedure consists of denuding the articulation of cartilage so that the bony surfaces may be approximated, but no effort is made to excise all diseased tissue. The advantage of this procedure is that a better mechanical correction of deformity can be secured, but as the stamina of the osseous tissue is poor in the infected area, union is slow and uncertain; also the possibility of instigating a more active process is great, and should secondary infection occur, the result may be disastrous. Intra-articular autogenous osseous grafts through the joints have been employed by the authors and others, and while apparently efficient for months, they later become absorbed and there is a return of motion. The intra-articular method is being discarded by most surgeons and supplanted as much as possible by extra-articular measures.

Intra-articular and Extra-articular Technic.—A combination of intra-articular and extra-articular procedures is more commonly employed with as little interference with the articular surfaces as possible. The capsule and synovial cavity are entered, so that autogenous osseous grafts may be placed in close approximation to the articular surfaces, which are denuded over a small area only, thus inducing

osseous fusion largely outside of the articular surface, but within the capsule.

Extra-articular Technic.—Extra-articular fusion is the induction of union entirely without the capsule of the joint, and should be secured in all joints if possible for the advantages of the procedure are obvious. If extra-articular arthrodesis is successful, intra-articular ankylosis usually follows. Fusion operations in the spine are entirely extra-articular and confined to normal bone, unless the process, as rarely occurs, has extended to the laminae and spinous processes. The author has employed a technic for extra-articular fusion which has proved successful in a small number of cases in the ankle, hip, and sacro-iliac joints, the principles of which may be applied to other joints. If fusion fails there is no danger of irritating the active process with the joint; if fusion results and later restoration of function is regarded as feasible, the extra-articular fusion can be easily excised, leaving all parts intact.

Tuberculosis of the Foot

Tuberculosis in the metatarsal bones and phalanges is rare and is known as spina ventosa, which is occasionally associated with generalized tuberculosis of the joints. The onset is gradual and the symptoms are pain, swelling, and induration, which can be easily palpated. Usually the shaft only is involved, but the joints at either extremity may be invaded in the late stages of the process. Tuberculosis of the metatarsals may require careful discrimination since a number of affections are quite similar. The roentgenogram demonstrates a slight proliferation and often destruction of the shaft. Syphilis is manifested at the onset by proliferation of the periosteum, but there is no destruction; in the late stage destructive changes may predominate, but there always remains sufficient characteristic hypertrophy of the periosteum from which the diagnosis may be made. Pain and tenderness are more apparent during the early stage of bone syphilis and persist until intra-osseous pressure has been relieved by destructive changes. The Wassermann test will aid in the differential diagnosis. In tuberculosis the process is destructive, slow, and insidious from the onset. In osteomyelitis the onset is acute with symptoms of a pyogenic infection, such as high temperature and leukocytosis. Should one of the metatarsal bones be fractured, there is a typical fusiform callus, which may obscure the point of fracture, but this usually recedes after a few weeks, while tuberculosis is slowly progressive. Osteitis fibrosa cystica is almost painless, and the characteristic pathologic process is clearly defined by the roentgenogram.

When tuberculosis is confined to one of the bones of the tarsus it may remain localized, or may extend to the adjacent bones, or to all the bones of the foot. In the tarsus the diagnosis may be made in the same manner, although care must be exercised not to confuse tuberculosis with Köhler's disease of the scaphoid, which is much milder and presents a characteristic roentgenological picture.

Treatment.—When tuberculosis is confined to one bone, a resection of the entire bone is indicated. Fixation for tuberculosis of the metatarsal bones may not be necessary, but when the tarsal bones are invaded an ankle splint or cast is employed. If the process is diffused throughout the tarsus, the treatment in children is conservative—fixation and heliotherapy. In adults, conservative treatment may be attempted, but amputation is often inevitable. Where conservative measures are used, fixation must be continued until the process is clinically arrested and the roentgenogram demonstrates condensation.

Tuberculosis of the Ankle

The ankle joint is more often invaded from a primary focus in the astragalus, or the process may begin in the metaphysis of the tibia and extend to all bones of the tarsus. In adults, and rarely in older children, the process may be of the synovial type resembling other types of low-grade infectious arthritis. The bony prominences, as the malleoli, become obscured, the swelling is of a boggy nature and may extend to the entire foot. Muscle spasm is present, but a fair degree of active motion may remain for months, or until there has been extensive destruction. Local heat and redness, at times, are also observed. Tenderness is present in all parts of the ankle joint, but exaggerated below each malleoli and over the superficial aspect of the neck of the astragalus. In the early stage atrophy of the calf muscles accentuates the swollen appearance of the foot and ankle, and as the process advances, there is contraction of the tendo achillis, and the foot is held in equinus. Secondary infection with pyogenic organisms is frequent, but is always a late complication, and may induce further destructive changes, with formation of multiple sinuses about the foot and ankle.

Diagnosis is not difficult, differentiation being made as described in the general discussion of Tuberculous Joints. At the onset the roentgenogram may demonstrate only an osteoporosis, but after months the destructive process in the astragalus or lower extremity of the tibia will be apparent with characteristic changes previously described.

In the synovial type the bone is not invaded until after a long period of time. The diagnosis can, at times, be made by biopsy alone.

Treatment.—The treatment differs in adults and children. Conservative measures with heliotherapy may be employed successfully in children, but are rarely practicable in adults on account of the length of time required to effect results, as the average person prefers amputation with a satisfactory artificial limb to indefinitely prolonged disability. In children, orthopedic apparatus is applied to maintain the foot at right angles to the leg and to remove the weight of the body from the foot. In rare instances, in both adults and children, the process may be confined to the astragalus, and eradication may be possible by excision of this bone. Amputation is seldom, if ever,

Fig. 114.—Tuberculosis of ankle with destruction of bone and narrowing of joint space. Anteroposterior view.

Fig. 115.—Same as Fig. 114. Lateral view.

indicated in children. In adults, if the diagnosis can be made before the process is diffused throughout the tarsus, operative fusion of the ankle joint is indicated. In those in whom the process has been arrested, with a painful joint from intra-articular incongruity and scar tissue, fusion is also indicated. Attempts to induce osseous fusion in the ankle joint are often beset with failure, especially when the operative procedure is confined to the interior of the joint. In adults, or in those with multiple sinuses or secondary infection, if the process does not subside after operative treatment, but continues to progress, amputation is advisable.

Technic.—Fusion can be accomplished with a greater degree of certainty by a procedure, which is largely, but not entirely, extra-

articular. A longitudinal incision is made, beginning about 4 inches above the ankle joint and about 1 inch internal to the fibula, and is

Fig. 116.—Extra-articular fusion of ankle joint. Posterior incision.

Fig. 117.—Same as Fig. 116. Anterior incision.

continued downward over the lateral aspect of the ankle joint, terminating on a level with the superior surface of the external cuneiform

bone. The superficial and deep structures are incised and the lower third of the tibia and the ankle joint are exposed. The superior surface of the neck of the astragalus is denuded. An osteoperiosteal graft about 4 inches in length is removed from the lower third of the tibia. The graft, together with small bone shavings from the anterior aspect of the tibia, is placed over the ankle joint in close proximity to the denuded surface of the lower extremity of the tibia and the denuded surface on the neck of the astragalus. A second skin incision 3 inches in length is then made over the posterior aspect of the ankle joint to the lateral aspect and parallel with the tendo achillis. Dissection is made between the tendo achillis and the posterior capsule of the ankle joint, care being taken to retract the extensor hallucis tendon inward. The posterior capsule of the joint is incised transversely. The

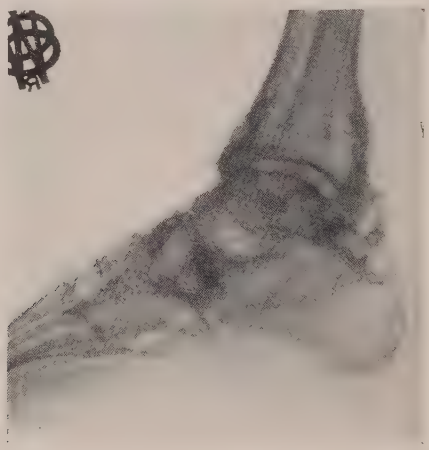


Fig. 118.—Ankle after extra-articular fusion for tuberculosis.

posterior extremity of the astragalus and the cartilage from the posterior portion of the ankle joint are removed. The posterior aspect of the tibia just above the ankle joint is denuded. A mass of bone is removed from the superior surface of the os calcis and placed in contact with the denuded posterior surface of the tibia and denuded surface of the os calcis. Both wounds are then closed and a plaster cast, extending from the toes to just below the knee, is applied, holding the foot in slight equinus, because with a stiff ankle this position facilitates walking. After any operation on the ankle joint, fusion results only after an elapse of considerable time. A cast should be worn for at least three months, after which a brace may be applied. The graft may be taken from the opposite limb when the quality of the bone on the affected side is deemed unsuitable.

Tuberculosis of the Knee
(Tumor Albus; White Swelling)

Tuberculosis of the knee joint occurs next in frequency to that of the hip joint. The disease is essentially one of early life, and is caused by localization of the Bacillus tuberculosis in one or more of the component parts of the joint. Either the femoral or tibial articulation may be first involved, rarely the patella, after which an evolutionary process with destruction occurs.

Symptoms and Diagnosis.—The first symptoms in the knee are stiffness, pain, and swelling, which gradually increase; local tenderness is found at varying points and local temperature is elevated. Atrophy above and below the knee is apparent early, and the bony landmarks are partially obliterated. On palpation moderate swelling of the entire joint with lobulated masses may be detected, although little excess fluid is present, except in those with synovial tuberculosis, when the entire joint may be markedly distended and fluctuating.

Fig. 119.—Tuberculosis of knee.

Fig. 120.—Tuberculosis of knee with beginning subluxation of tibia.

In children the knee is held in flexion of about 30 degrees and active and passive motion is limited, but not obliterated by muscular spasm. The process in adults is more indefinite and insidious than in children often persisting for years with comparatively slight inconvenience.

Muscular spasm is rarely present and motion in adults is often limited only in full extension and extreme flexion. After there have been gross destructive changes the tibia often subluxates and rotates outward with valgus—a malposition which renders weight-bearing difficult, even after the process is apparently arrested. In adults extensive destructive changes may occur in all bones forming the articulation, but extensive deformity occurs less frequently than in children. As the knee joint is an almost subcutaneous joint, abscess and secondary infection with sinus formation are frequent. In the early stage, in both children and adults, the roentgenogram is negative, and even

Fig. 121.—Tuberculosis of knee with erosion of articular surfaces. Anteroposterior view.

Fig. 122.—Same as Fig. 121. Lateral view.

for months after the onset of the process there are no bone changes apparent, the only difference, when a comparison of the two knees is made, being an increased density and swelling of the soft tissues due to an accumulation of fluid in the joint and a slight osteoporosis of the articular extremities of the bones. In the more advanced stages the joint space becomes narrowed and the articular surfaces eroded. As in all tuberculous processes of the bones and joints, the typical manifestation is bone destruction, there being little evidence of new bone production, unless the process is contaminated by a secondary

infection. Even in the advanced stages, when the process is apparently arrested, bony ankylosis, as a rule, is not demonstrable, the joint line remaining as evidenced by a narrow dark line on the roentgenogram.

Prognosis.—The process in children is usually arrested with efficient treatment in two or three years, but rarely terminates in osseous fusion. Recurrence or relighting of the infection is said to be quite frequent in the knee, and the question of a permanent cure in this region is debatable. In adults, the prognosis is unfavorable with conservative treatment and much better where osseous fusion is secured early by operation.

Treatment.—In children orthopedic measures of fixation and traction are applied to secure and maintain the knee in extension until the disease process has become arrested; this requires from two to three years of continuous heliotherapy and other antituberculous measures carefully administered. Operations for the purpose of fusing the joint have been recently advocated, even in young children, but as yet sufficient evidence has not been accumulated to establish this method as a standardized procedure. In adults, the conservative treatment is reserved for those in whom operative measures are contraindicated, and when possible, the fusion operation is the accepted procedure. Excision of the knee in children and adults is obsolete and must not be confused with the operation for fusion. The purpose of operation for tuberculosis of the knee is to induce ankylosis or fusion. This may be accomplished by several different methods, the principles of which may be described as follows:

Intra-articular Technic.—The incision is begun 3 or 4 inches above the patella just internal to the quadriceps tendon, passes downward medially to the patella, and terminates at the tibial tubercle. The skin, superficial and deep fascias, and capsule are incised. Dissection is made between the vastus internus and rectus femoris muscles, after which the capsule of the joint is incised throughout the entire length of the incision. Retractors are inserted which afford an excellent exposure of the joint. When the interior of the joint is reached, the crucial ligaments are severed, giving free access to all articular surfaces. The incrusting cartilage with a thin layer of superficial bone from the tibia and femur is excised with a jig-saw. If desired, the posterior surface of the patella and the corresponding portion of the femur are denuded; the entire patella may be excised. The knee is extended and the denuded osseous surfaces are closely approximated. If possible, the knee should be maintained with such approximation

at an angle of about 150 degrees flexion, as this is the most serviceable position for walking and sitting. Long steel nails are at times employed to hold the articular surfaces in contact for several weeks.

Intra-articular and Extra-articular Technic of Hibbs.—A U-shaped incision is made to sever the patellar tendon close to its insertion, and the entire flap, including the patella and patellar tendon, is turned upward. The patella is denuded of its tendinous attachments, by dissecting around the circumference leaving the bone adherent by a small central pedicle. All cartilage is removed from the patella, femur, and tibia. A bed for the patella is then prepared by chiseling on the femur and tibia, and the patella is implanted by wedging it in these grooves as the knee is extended. The patellar tendon is then sutured and the wound closed. The joint proper is invaded to a slight extent only, the patella acting as a graft to unite anteriorly the femur and tibia. With the patella in this position a perfect bony bridge is formed between the tibia and the femur. This is a distinct advantage, as there is less disturbance of the tuberculous process and less surgical reaction. The healing process is hastened, there is less drainage, and the chances of secondary infection or relighting an active process are materially decreased. When a sufficient osseous bridge is difficult to obtain by employing the patella alone, the author places osteoperiosteal grafts from the tibia to reinforce fusion. These grafts are attached to the anterolateral aspects of the tibia and femur.

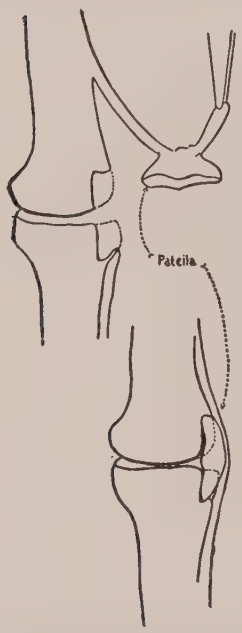


Fig. 123.—Technic of Hibbs' fusion of knee. (Steindler, Text-book of Orthopedic Surgery, plate 60, p. 261, D. Appleton.)

After-treatment.—As postoperative treatment following any technic, a plaster cast extending from the toes to the crest of the ilium, with a window over the incision, is the best method for complete fixation of the knee joint. At the end of twelve weeks if fusion has progressed sufficiently a Thomas caliper knee brace is applied, with a leather corset attached which snugly encases the limb. Accurate conformation to the contour of the limb is secured by first making a plaster model and molding the leather to the model. This apparatus is suitable for constant use, day and night, until fusion is solid. Apparatus must not be discarded

until the roentgenogram demonstrates complete organization of the osseous union, which usually requires about six months.

Malposition or deformity persisting for two or three years after the arrest of the tuberculous process should be corrected by extra-

Fig. 124.—Knee after fusion for tuberculosis. Anteroposterior view.

Fig. 125.—Same as Fig. 124. Lateral view.

articular procedures, as osteotomy of the femur, just above the joint. However, in those cases in which there is deformity with painful motion, the correction of the deformity and fusion should be made within the joint.

Tuberculosis of the Hip

The site of tuberculous invasion of the hip joint in children is more frequently the upper femoral epiphyses; in adults, the primary focus is usually in the head of the femur. The invasion occasionally begins in the acetabulum. The synovial type of tuberculosis is seldom observed in the hip.

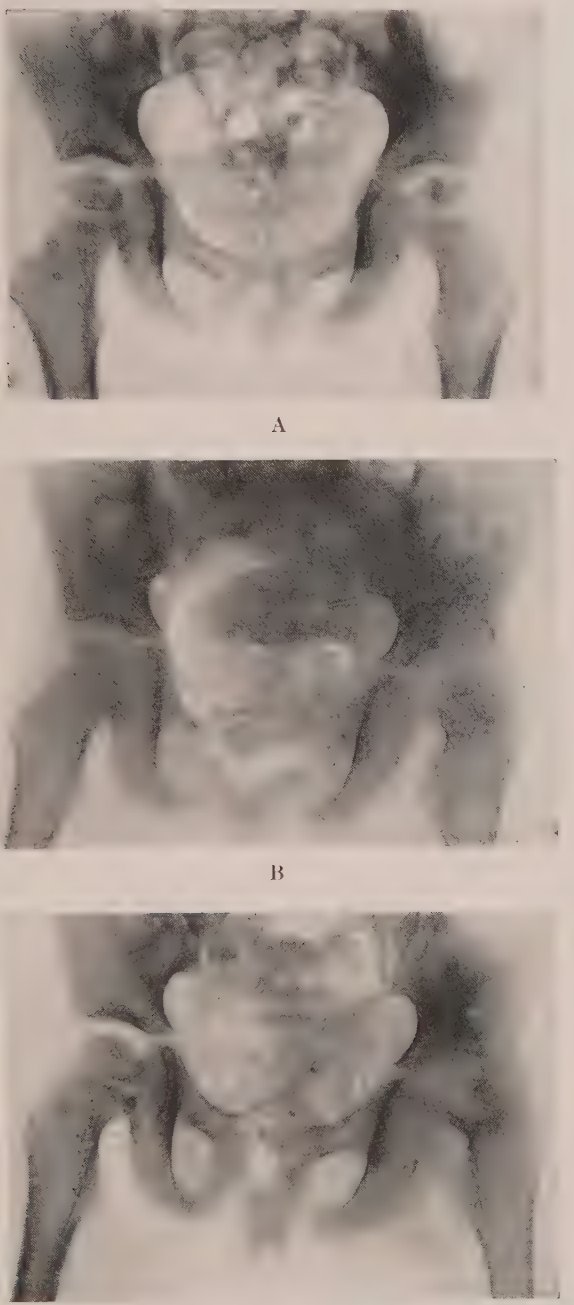
Symptoms.—In children the first apparent abnormality is an early morning stiffness with lameness which disappears in a few hours. As the process advances the limp becomes more pronounced and continues throughout the day. Pain is almost invariably referred to the

knee, but may also be present in the hip. Night-cries are more frequent and more severe than those observed in tuberculosis of any other joint. Atrophy is observed earlier than in tuberculosis of other joints,

Fig. 126.—Early tuberculosis of hip with flexion contracture.

and also to a greater degree in tuberculosis of the hip than in other hip affections. On palpation, induration and swelling may not be apparent early, but are always present when the process is well advanced, being first manifested on the anterior aspect of the joint, and later surrounding the entire joint. Active and passive motion are obliterated by muscular spasm which is more intense and continuous in the hip than in any other joint, and is often manifested to such an extent that there is complete fixation as if ankylosis were present. At the onset the hip is held in flexion, abduction and external rotation, and the affected leg seems longer. After extensive destruction, there is organic deformity and the hip is flexed, adducted, and rotated inward with actual and apparent decrease in length. The gluteal fold in the early stage is below that of the normal side, and after extensive destruction is above the normal level of the fold. Apparent increase and decrease in length are obviously due to malposition with tilting of the pelvis. Occasionally there may be actual increase in length from proliferation of the upper femoral epiphyses, but not of sufficient degree to be of any harm. The acute stage of tuberculosis of the hip is rarely seen in adults. The process begins insidiously with pain and restriction of motion. The symptoms of muscular spasm, atrophy, and swelling are not so acute as in children. Ab-

Fig. 127.—Tuberculosis of hip showing flexion and adduction contracture and multiple scars of healed sinuses.



A

B

C

Fig. 128.—Tuberculosis of hip. A, Slight decrease in joint space and loss of density in head of femur. B, Progressive destruction with erosion of head of femur and acetabulum. C, Further destruction of joint with disintegration.

scesses may be apparent as fluctuating masses over the greater trochanter or posterior aspect of the hip. Rarely, abscesses may break through the acetabulum into the pelvis, forming perirectal abscesses, or may rupture into the rectum. Secondary pyogenic infection as a late manifestation is evidenced by symptoms of sepsis. A multiplicity of sinuses in all directions is not uncommon in neglected cases.

The evolution of the pathologic process can be followed by the roentgenogram. Osseous involvement is first apparent by ill-defined areas of necrosis near the epiphysis, which gradually undermines the incrusting cartilage and superficial bone until the joint is invaded, when there is gradual erosion with destruction of the articular surfaces and adjacent bone. The acetabulum may be destroyed and the head of the femur may be dislocated. The head and neck of the femur may disappear so that the trochanter approximates the pelvis. Abscesses are a late manifestation and are diagnosed by intracapsular and extracapsular swelling and induration. If efficient orthopedic measures are instituted early and maintained throughout, the destructive process is more often restricted.

Diagnosis.—Certain affections of the hip—psoas abscess, syphilis, subacute stage of acute infectious arthritis, low-grade infectious arthritis, coxa plana, and coxa vara—must be carefully differentiated from tuberculosis of the hip. In psoas abscess there is a definite limp, but the range of motion is limited chiefly in extension. A mass can often be elicited above Poupart's ligament, and there may be manifestations referable to a lesion of the spinal column. In tuberculosis of the hip, in addition to the symptoms and physical signs, motion is limited in all directions. After destructive osseous lesions are present the roentgenogram will differentiate the two conditions. In syphilis, the symptoms are not acute until there has been extensive osseous destruction. The roentgenogram, blood, and spinal-fluid Wasserman, and therapeutic test are all of value in discriminating the two affections. Acute infectious arthritis, during the subacute stage, when monarticular, is often mistaken for tuberculosis, but may be diagnosed by the history and the roentgenogram. When low-grade infectious arthritis is confined to one joint, differentiation may be difficult or impossible until many months elapse. The symptoms are less pronounced than in tuberculosis. The roentgenogram demonstrates a characteristic mottling of the osseous structure of the femoral head and neck, often with hypertrophy of the neck, whereas tuberculosis is an atrophic and destructive process. In adults, monarticular arthritis of the atrophic type may also be ruled out by the symptoms and the

roentgenogram. Coxa plana has so frequently been mistaken for tuberculosis as to render all except recent statistics of tuberculosis of the hip unreliable. Coxa plana occurs during the middle years of childhood, between the ages of five and ten, while tuberculosis occurs more frequently in early childhood, from three to five years of age. In coxa plana, the motion is limited chiefly in two directions, abduction and internal rotation, while in tuberculosis the motion is limited in all directions. Muscle spasm in coxa plana is mild and in tuberculosis is severe. Occasionally, in coxa plana, when the process is very acute, the symptoms may be exaggerated and a differentiation may be impossible without observation over a period of time. The roentgenogram demonstrates characteristic changes, which are quite different from those of tuberculosis. In coxa vara, or separation of the upper femoral epiphyses, the symptoms are almost identical with those of coxa plana, except that the hip is frequently rotated outward. Coxa vara is always observed in the period of adolescence. It is also more frequently observed in the effeminate type of individual with endocrine disturbance, as indicated by excessive fat and undeveloped genital organs, though coxa vara also occurs in apparently normal individuals. In coxa vara the roentgenogram demonstrates typical epiphyseal separation that confirms the diagnosis.

Prognosis.—The mortality in tuberculosis of the hip joint is comparatively low in those securing early and efficient treatment, and high in those who are neglected. Conservative measures alone may undoubtedly check the process, but rarely can one be certain of a complete arrest or cure. In adults, the chances of recovery are excellent by early operative fusion, but much less after the process has been advanced. Extra-articular fusion operations are better adapted to the hip than to any other joint, as the neck of the femur and ilium are in close proximity and may be united with minimum interference of the joint proper. In children, however, fusion operations can not be accepted as standardized procedures until more proof has been submitted as to the results secured, and tuberculosis of the hip joint, as of the knee, may be arrested by conservative measures and heliotherapy. Restoration of function should be neither expected nor desired after any form of treatment, as the less motion present, the better the prospect of a permanent cure. Secondary infection with draining sinuses is a more serious complication than in other joints, as the surrounding cavernous spongy bone and the mass of surrounding soft tissues form an excellent medium for the ramification of the sinuses and the formation of pus pockets. Tuberculous meningitis occurs more frequently

as a late complication of tuberculosis of the hip than of any other joint and is always fatal.

Treatment.—The conservative treatment consists in the maintenance of the hip in the most useful position for future use. This is accomplished by a plaster cast or other apparatus designed to meet individual requirements. When contractures are present before structural organization of tissues occurs, correction of deformity should be made very gradually by special apparatus and never by sudden force, as tuberculous meningitis from metastasis is an imminent danger.

Operative attempts to secure intra-articular fusion of the hip by inducing bony contact between the head of the femur and the acetabulum have usually failed. There are several methods largely or completely extra-articular, which are far superior, as they are less likely to instigate acute exacerbations. The one most commonly employed was first described by Haas, but in this country has been advocated by Hibbs.

Hibbs' Technic.—An incision beginning 2 inches behind and above the anterior superior spine is made through skin and subcutaneous tissue down over the greater trochanter and prolonged 3 inches on the shaft of the femur. The deep fascia is split, the tensor fascia femoris retracted medially, and the fibers of the gluteus medius and minimus separated by blunt dissection, exposing the capsule. The periosteum of the femur is incised along the line of the base of the trochanter, elevated and retracted medially; the anterior three fourths of the trochanter with 2 inches of the cortex of the femur is separated with a chisel, leaving the muscle and periosteal attachments undisturbed. The capsule is split, the superior aspect of the neck exposed and the cortex removed. A mass of the ilium, including the upper rim of the acetabulum is elevated without disturbing the muscle or periosteal attachments or breaking loose the mass above. The trochanter is now rotated and its lower end transposed under the elevated mass of the ilium, its base making snug contact with the cancellous bone of the neck. The periosteum of the transposed bone is sutured to that of the iliac mass above and to that of the femur below. The mass is also caught by the tip of the remaining one fourth of the trochanter; when the thigh is abducted 15 degrees and flexed 30 degrees, it is held securely in place. The muscles and fascia are closed with sutures of plain catgut, the subcutaneous tissues with plain gut, and the skin with silk. A double spica plaster cast which has already been prepared and bivalved is then applied. It is evident that this procedure is largely extra-articular, but invasion of the joint is necessary, as a large portion

of the neck of the femur is enclosed by the capsule. More stable fixation results, if osseous union is secured, in the angle between the neck and the ilium, in addition to the extra-articular fusion.

Albee's Technic.—Albee employs the inlay graft to induce extra-articular fusion. Through a semicircular incision the greater trochanter and side of the pelvis just posterior to the anterior superior iliac spine are exposed by separating the fibers of the gluteal muscles. The trochanter is split vertically with a motor saw and flaps of bone are turned each way by means of a broad osteotome. Two indentations are made about 2 inches apart in the lateral wall of the ilium midway between its crest and the roof of the acetabulum, the first indentation being about $\frac{1}{2}$ inch posterior to the anterior superior spine. A straight graft about 4 to 6 inches in length is removed from the tibia, and split longitudinally with a motor saw, forming two grafts, the ends of which are beveled. The beveled wedge-shaped ends are driven into the indentations in the ilium. The distal ends of the grafts are implanted in the split trochanter and the bone flaps of the latter are secured by kangaroo tendon. Numerous fragmented particles, obtained from beveling the ends of the grafts, are placed about the pelvic and trochanteric extremities of the inlays. After closure of the wound, a plaster-of-paris spica is applied from the toes to the costal border, the limb being placed in slight abduction and flexion.

Osteoperiosteal Graft.—In young children the author has employed an osteoperiosteal graft for inducing fusion of the hip. The incision made is similar to that employed by Hibbs in fusion of the hip. The trochanter and upper shaft of the femur are exposed and the cortex denuded. A corresponding area is denuded on the ilium just above the margin of the acetabulum. The capsule of the joint is not opened and the head and neck of the femur are not exposed. An osteoperiosteal graft is removed from the tibia and placed across the joint, making contact with the ilium above and the shaft and trochanter of the femur below. The fragments of bone from the femur and ilium are preserved and packed about the osteoperiosteal graft and the wound closed. Extra-articular fusion and extra-articular correction of skeletal deformity may be carried out at the same operation. In older children and in adults in whom there is a sufficient amount of bone present in the region of the hip joint, fusion of the joint may be accomplished without the transplantation of bone from other parts of the body. A Smith-Petersen incision is made over the affected hip; the muscles are stripped from the ilium; the upper surface of the ilium and the greater trochanter and the upper shaft of the femur are exposed; the

superior surface of the neck of the femur is denuded and multiple fragments of bone are chiseled from the ilium and from the trochanter of the femur and placed across the joint line. This method is of value, but can only be employed when there is sufficient healthy bone in the region of the joint to induce fusion; such bone is not always available when there has been extensive destruction of the hip joint and atrophy of the surrounding bone structure.

After-treatment.—The postoperative treatment is the same following any technic. In children the hip should be placed in complete extension in a straight line with the body at about 160 degrees abduc-

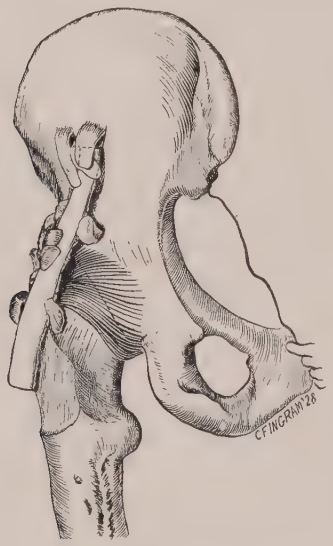


Fig. 129.—Technic of extra-articular fusion of hip, using osteoperiosteal graft.

Fig. 130.—Hip following fusion for tuberculosis.

tion, and in the midposition between internal and external rotation. Even in this position, as the process develops and the growth of the child increases, the tendency is for flexion to occur. In adults about 160 degrees flexion is the position of choice, in addition to abduction and a midposition between internal and external rotation. This position is maintained by a plaster cast which extends from the toes to the nipple line on the affected side, and to just above the knee on the normal side. Walking is permitted in a cast at the end of eight weeks. The plaster cast remains until union is solid, which, in adults, requires about four months and in children eight months. A brace is then applied to permit walking and also to maintain the most useful position. Apparatus should be worn until osseous fusion is completely organized

and there is no danger of deformity. After the removal of the apparatus, adults should be carefully observed for at least one year, and all children for several years, as deformity may occur from irregularity of growth due to invasion of epiphyses and nonelastic soft structures.

Treatment of Deformities.—Malposition and distortion of the hip are corrected by operative procedures which should be entirely extra-articular, and consist in the severance of all contracted soft structures and an extra-articular osteotomy just below the greater trochanter. The adductors may always be divided subcutaneously, but if flexion contraction is severe, the flexor muscles should be exposed and stripped from their attachments on the ilium. For the correction of skeletal deformity, an osteotomy is done just below the greater trochanter, with a curved wood-carver's chisel, as described by Brackett, but unless the correction is also made in the soft structures, there may be gross displacement of the lower fragment. In malposition and deformity, when ankylosis is not present, fusion and intra-articular correction of deformity may be accomplished at the same time. Improvement of ambulatory function is more strikingly obtained by correction of deformities of the hip than in any other condition. Motion of the lumbar spine largely compensates for ankylosis of the hip, and walking is often possible with only a slightly perceptible limp. Excision of the hip is obsolete in children and rarely, if ever, indicated in adults. This procedure is dismissed with brief mention as it usually is mutilating and unnecessary.

Tuberculosis of the Sacro-iliac Joint

Tuberculosis of the sacro-iliac joint occurs less frequently than tuberculosis of the spine and hip joint; both sacro-iliac joints may be affected, though the condition is usually unilateral. The primary focus is commonly located in the lateral mass of the sacrum and may be due to extension from tuberculosis of the lower lumbar vertebrae. Abscess formation is of frequent occurrence and meningitis is often a complication. Pain and tenderness are the first symptoms; pain may be referred along the distribution of the lumbosacral plexus, as in other sacro-iliac joint affections. Tenderness on pressure directly over the joint is usually present. Kernig's sign is positive and the other tests for sacro-iliac diseases, such as pain on compression of the iliac crests and Gaenslen's sign may be positive. Motion of the lower lumbar spine is restricted and the characteristic attitude of sciatic scoliosis may be assumed. Abscesses may form, causing pain posteriorly in the lumbar or gluteal regions, and may later rupture and become secondarily

affected and form numerous sinuses. The roentgenogram of the sacro-iliac joint is often unsatisfactory and does not demonstrate any changes until there has been extensive destruction. In the advanced stage the articular surfaces of the sacrum and ilium are eroded, the joint space appears broader than normal and the area is surrounded by a shadow of increased density, indicating abscess formation.

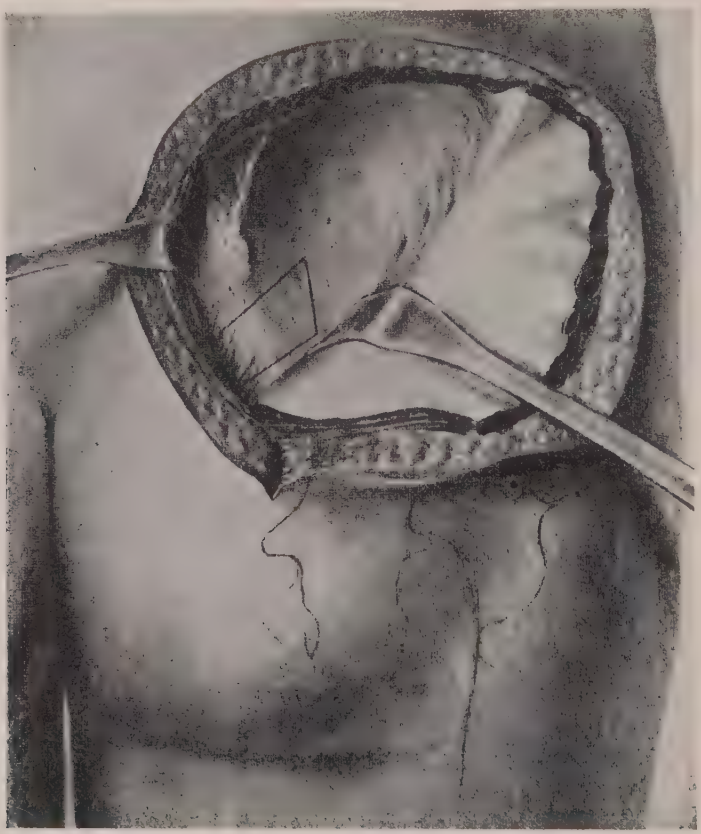


Fig. 131.—Smith-Petersen technic for fusion of sacro-iliac joint. A window is outlined on the ilium, extending posteriorly into the inferior sacro-iliac ligament. (From Smith-Petersen and William A. Rogers in Jour. of Bone and Joint Surg., vol. viii, p. 118, 1926.)

Prognosis.—The prognosis is most unfavorable in the majority of the cases, and when secondary infection occurs the patients, especially adults, do not recover. The prognosis is more favorable when fusion operations are performed early. Tuberculous meningitis is a frequent and fatal complication; abscess formation with rupture and secondary infection is also quite frequent, and, according to statistics, the inci-

dence of coincident pulmonary tuberculosis is higher in affections of this joint than in other joints.

Treatment.—The conservative forms of treatment, as recumbency, casts, and braces combined with antituberculous measures and heliotherapy are seldom sufficient to arrest the process. The operative fusion of the sacro-iliac joint affords the most satisfactory method of treatment, except in the advanced stage with abscess formation, as the probability of securing osseous fusion during the destructive stage is less. The joint may be fused by one of the following methods:

Smith-Petersen Arthrodesis.—An incision is made along the posterior two thirds of the iliac crest curving around the posterior superior

Fig. 132.—The window is countersunk and the overhanging edges of the window turned down with a chisel. (From Smith-Petersen and William A. Rogers in Jour. of Bone and Joint Surg., vol. viii, p. 118, 1926.)

spine, and then running parallel with the fibers of the gluteal muscles a distance of 2 to 3 inches. The soft tissues are reflected subperiosteally, exposing the lateral surface of the ilium. A window, extending posteriorly into the inferior sacro-iliac ligament, is then removed from the ilium. The cartilage on the sacral joint surface is cureted exposing cancellous bone. After removing the cartilage from the joint surface of the block of bone, the same block is replaced and countersunk so that the cancellous surface comes into contact with the cancellous bone of the sacrum. The countersunk block is further secured and osteogenesis promoted by turning down flaps of bone from the edges of the window.

Gaenslen Arthrodesis.—Through a curved incision the posterior third of the ilium is divided into an outer leaf which is reflected laterally with the muscles attached and an inner leaf which remains standing. A triangle is marked out on the remaining leaf within the articulating area of the joint. The bone is removed from this triangular area and preserved; the articular cartilage from both the ilium and the sacrum is removed, exposing the cancellous bone of the sacrum. The bone fragments of the ilium which were preserved are packed into the triangular area and the outer leaf of the ilium replaced and sutured into position.

Extra-articular Arthrodesis.—Fusion operations which enter the sacro-iliac joint are likely to be followed by secondary infection with

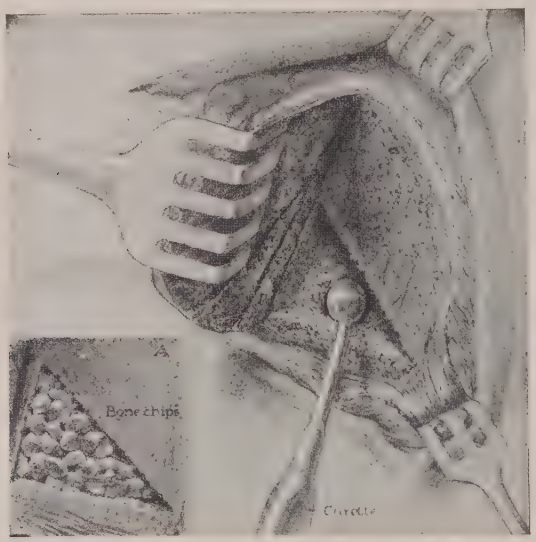


Fig. 133.—Gaenslen technic for fusion of sacro-iliac joint. (F. J. Gaenslen in Jour. Amer. Med. Assoc., December 10, 1927.)

discharging sinuses which may terminate fatally. The author employs a simple operation which is entirely extra-articular, thus avoiding any possibility of contamination within the joint. An incision is made along the outer lip of the crest of the ilium from the posterior one third or one half to the posterior inferior spinous process (Smith-Petersen). This is carried down to the bone, where the periosteum is incised and elevated for a considerable distance, thus exposing the posterior portion of the dorsum of the ilium. The crest of the ilium is dissected and the adjacent fibrous tissue removed from the posterior surface of the sacrum beneath the region of the erector spinalis and sacrospinalis muscles. A portion of the crest is removed and preserved in a towel.

Fig. 134.—Incision for extra-articular fusion of the sacro-iliac joint, exposing outer half of posterior surface of sacrum and posterior half of crest of ilium.

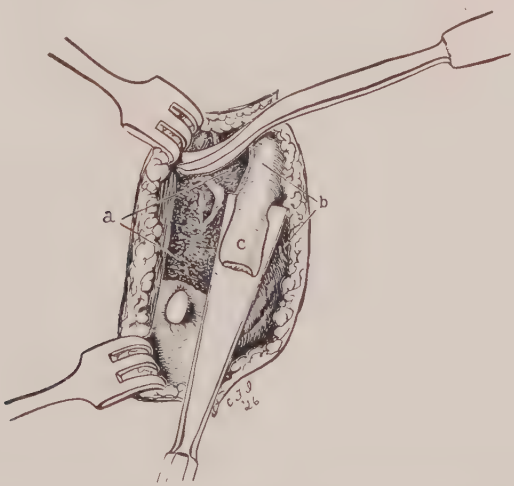


Fig. 135.—Removal of a portion of crest of ilium: *a*, Sacrum; *b*, ilium; *c*, fragment from crest of ilium.

The inner surface of the overhanging portion of the crest of the ilium and the adjacent posterior surface of the sacrum are denuded, thus making a raw gutter parallel with the sacro-iliac joint, formed by the

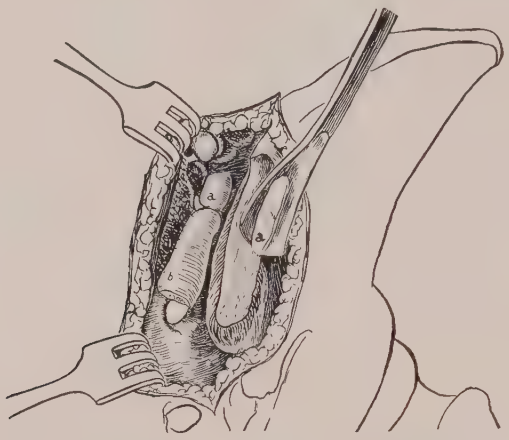


Fig. 136.—Placing of multiple chips into denuded gutter formed by posterior surface of sacrum and inner surface of dorsum of ilium: *a*, Small bone particles; *b*, large bone fragment.

posterior surface of the sacrum and the inner surface of the ilium posterior to the sacro-iliac joint. Into this space is placed the graft from the crest of the ilium. Multiple grafts or shavings are next secured

Fig. 137.—Multiple grafts completely filling the denuded gutter.

from the dorsum of the ilium and placed into the gutter until the space is well filled. The wound is closed in layers, and the patient placed on a Bradford frame for a period of six weeks. Frequently, the lumbo-

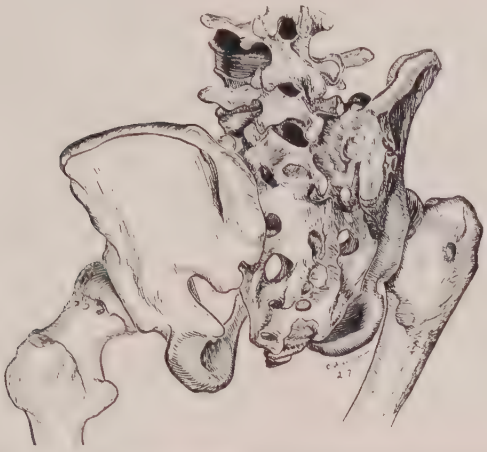


Fig. 138.—Fusion between sacrum and ilium posterior to sacro-iliac joint.

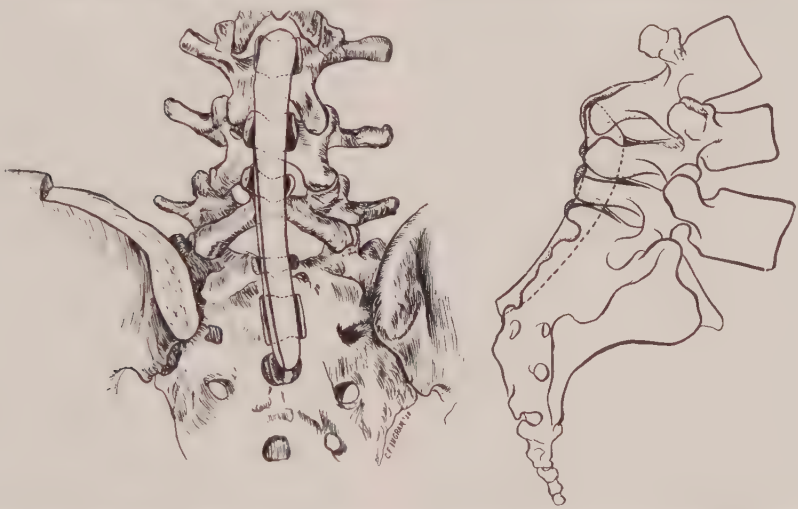


Fig. 139.—Fusion of lower lumbar vertebrae and sacrum, using a curved graft from crest of ilium.

sacral joint must also be fused. The graft from the crest of the ilium may be employed for this purpose by inserting it into the spinous processes of the lower lumbar vertebrae and sacrum, after the manner of Albee.

Tuberculosis of the Spine
(Pott's Disease)

Tuberculosis of the spine usually originates from a primary focus in the anterior portion of the body of a vertebra. The entire body is gradually invaded and there may be an encroachment of the process upon a number of vertebrae by direct extension, though the destruc-

tion is rarely as extensive in these as in the vertebra where the process develops originally. Less frequently the infection may have its origin in the intervertebral disk. The laminae and spinous processes also are rarely, if ever, the site of the primary invasion, and are seldom involved by continuity. In an occasional instance, two or more foci may develop simultaneously in different regions of the spine.

Symptoms.—The outstanding symptoms are referred pain, muscular spasm, and deformity. However, the clinical manifestations vary sufficiently in the different portions of the spine to warrant a separate description of the symptoms common to each region. When the disease affects the lumbar region, pain is usually felt on the anterior aspect of the thighs. Muscle spasm is exaggerated, and the entire spine is

Fig. 140.—Tuberculosis of upper dorsal spine. Note elevation of shoulders to relieve weight of spine.

Fig. 141.—Early tuberculosis of dorsal region. Note rigidity of spine from muscular spasm.

held rigid, which is quite apparent, especially in children, when the patient stoops to pick up objects from the floor. Lordosis is increased and the abdomen becomes prominent and distended with gas; the gait is swaggering but very guarded. Sensitiveness to slight jars is frequently observed. Tenderness on palpation or percussion over the spinous processes may or may not be present. The psoas muscle, which is attached to the lumbar vertebrae, may be irritated and contracted, causing a limp, which is occasionally the first noticeable symptom. Deformity occurs late and is not so extensive as in the dorsal region, for the normal contour of the spine is convex forward; conse-

quently disintegration in the bodies of the vertebrae does not induce the column above to fall forward by the force of gravity. As a result, if the process is not arrested, there will be a somewhat angular posterior kyphos with compensatory lordosis above and a flattening of the entire chest. The stature is never so extensively decreased as it is when the dorsal region is affected.

Deformity is more pronounced in the dorsal region, as the destruction is on the concave side of the vertebral column. Deformity in this region is manifested by an angular kyphos, lateral compression of the thorax, and a prominent chest (pigeon breast). The length of the trunk may be so decreased that the extremities appear much out of proportion. In the middorsal and lower dorsal regions, pain is often referred to the abdomen, and may closely simulate acute inflammatory affections of the intestinal tract. In fact, symptoms are often apparent in the abdomen for many months before the deformity of the spine is observed, which is due to failure to examine the spine routinely. The gait may be guarded and the child may often stumble. The knee reflexes are often exaggerated without other evidence of myelitis. In the upper dorsal region, pain is often referred to the lateral aspect

Fig. 142.—Tuberculosis of lower dorsal spine with kyphos.

Fig. 143.—Tuberculosis of upper lumbar spine with angular kyphos.

of the chest. The shoulders are elevated in an effort to remove the weight from the spine. As the spine is normally fixed by the attachment of the ribs, muscular spasm may not be grossly apparent, but is always present and can be detected by close observation. The first noticeable sign is usually the small "knuckle" or prominence of one spinous process. If not arrested, a rounded kyphos develops, which involves the upper ribs, and the anterior aspect of the chest becomes flattened above and protuberant below. The thorax is compressed laterally and there is a compensatory flattening or lordosis of the spine below the lesion. There is an expiratory grunt which is constant when the process is acute, and otherwise only on exertion, as in walking or running. This is due to pain from excursion of the chest wall and is often exaggerated when excessive exudate or abscess is present. When the involvement is above the seventh dorsal vertebra, the child often sits with the elbows on a table, the chin supported by the hands, in an effort to relieve pain by decreasing superincumbent weight, and unconsciously making head traction.

In the cervical vertebrae below the axis there is marked spasm of all muscles, and the neck is flexed and held to one side in torticollis. Pain may or may not be present at the side of the neck, and when present is occasionally referred to the arms. There may be an effort to support the head by the hands. If deformity is not prevented, the neck may become permanently fixed in extreme flexion with the eyes directed to the feet.

When the upper two cervical vertebrae are involved, the local symptoms are apparent early, as this portion of the spine is normally flexible. The head is held rigid with the chin in the midline and usually elevated, although the head may rarely be depressed with the neck in flexion. Passive and active motion is limited by muscular spasm, pain is referred to the occiput and the gait is guarded. When an abscess forms it points anteriorly and may be seen and palpated on the posterior wall of the pharynx, where it interferes with respiration and deglutition.

The symptoms and clinical course are transitional. For example, in passing from one region of the spine to another, as from the cervical to the dorsal, there is a gradual change in the anatomical characteristics of the vertebrae. In the same manner, there is a change in clinical manifestations. Tuberculosis at the junction of the dorsal and cervical regions will show symptoms characteristic of both the cervical and dorsal areas; the same transition is observed in the dorsal and lumbar regions. The symptoms in adults may be more indefinite than in children, with

a prolonged evolutionary period. Abscess is a most frequent complication and may be manifested by pressure symptoms or the roentgenogram before the fluctuating mass becomes apparent externally. Paralysis of the lower extremities is observed more often when the dorsal region is involved and is almost unknown when the lumbar region is affected. The upper extremities are rarely paralyzed, even when the lesion is in the upper cervical vertebrae. The pathology of the paralysis is a transverse myelitis from toxic exudates; the paralysis may be caused by mechanical pressure of the exudates, but rarely by bony pressure, regardless of the degree of deformity. The first symptom is muscular stiffness on walking and as the paralysis increases, the muscles become more spastic with exaggeration of reflexes until finally locomotion is

Fig. 144.—Limited extension of hips and spine due to irritation of psoas muscle.

impossible. In neglected cases as the destructive changes in the spinal cord progress, the paralysis becomes flail or loose and trophic changes occur. It would naturally be expected that tuberculous meningitis would complicate tuberculosis of the spine more frequently than tuberculosis of other joints on account of the close proximity of the process. However, meningitis is a less frequent complication of tuberculosis of the spine than of the hip.

Roentgenoscopy.—There should be a systematic roentgenological examination of the entire spine when a lesion of the vertebral column is suspected. The roentgenogram of the cervical region may be omitted if the physical examination of this region is negative, but should there be the slightest suggestion of abnormality, the cervical spine should also be included in the examination. Two views should be made, an anteroposterior and a lateral, and in the lumbosacral region stereoscopic

roentgenograms are frequently required; otherwise, pathologic changes may be overlooked. In adults, structural changes may not be apparent in the roentgenogram until the elapse of many months or even years. The first evidence of tuberculosis revealed by the roentgenogram is usually a decrease in width of the intervertebral disk, or a punched-out appearance along the superior or inferior borders of a body, or there may be small rarefied areas in the body of the vertebra. As the process advances, there will be a gradual destruction with wedging of the body, demonstrated in the lateral view, and a compression with de-

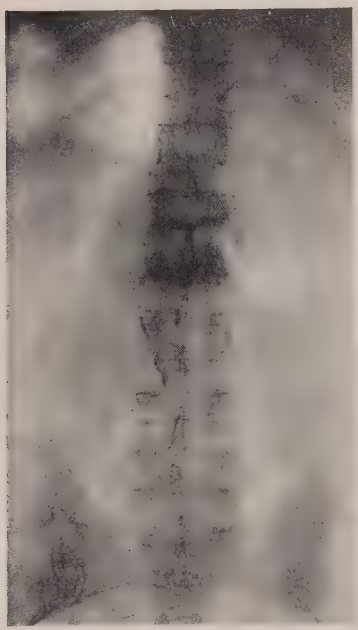


Fig. 145.—Tuberculosis of spine with narrowing of intervertebral space. Antero-posterior view.

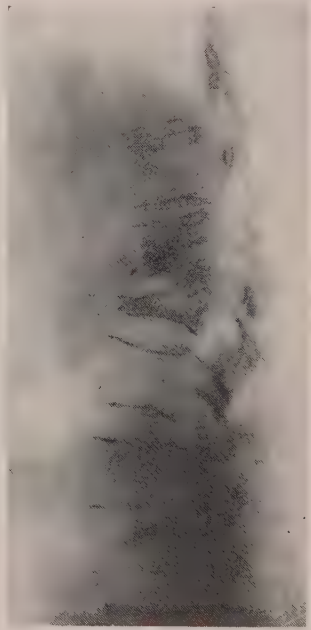


Fig. 146.—Tuberculosis of spine with narrowing of intervertebral space and erosion of anterior margins of body of vertebrae. Lateral view.

crease in dimension from above downward apparent in the antero-posterior view. There will also be structural changes of atrophy and necrosis throughout the affected area. In the dorsal region, a mass of exudate surrounds the vertebrae and is apparent in the roentgenogram as an oblong, circumscribed shadow of increased density. During the process of healing, this mass often undergoes calcification. Abscesses may also be outlined in this region by definite shadows. Evidences of inflammatory exudate may also be seen in the cervical and lumbar regions, but are never so pronounced as in the dorsal region.

Prognosis.—As in the hip joint, the mortality is high in neglected cases and low in those receiving efficient treatment from the onset. In early childhood, when the disease is most frequent, and dependence must be made upon conservative measures alone, the prognosis is more unfavorable than it is in later life. The disease in the cervical region is followed by the highest percentage of recoveries, while the lowest is in the dorsal region, the disease of the lumbar region being intermediate between these two. Prevention of deformity is not always possible, but with efficient treatment, the degree of deformity may be

Fig. 147.—Tuberculosis of lower dorsal area with destruction of bodies and extreme kyphos.

slight. In the dorsal region deformity is more frequent and more pronounced regardless of the type of treatment employed. The process may be arrested even in adults by conservative treatment and heliotherapy, but the best chance for successful termination in late childhood, adolescence, and adults, is afforded by fusion of the spine in addition to orthopedic measures and heliotherapy.

Treatment.—*Nonoperative Treatment.*—Apparatus must be constructed to secure fixation and must also be adapted to the mechanical requirements of the region affected. When the process is acute, re-

cumbency with spinal fixation is necessary and must sometimes be continued for one or two years. For this purpose, when the cervical or upper dorsal regions are affected, the patient is placed upon a Bradford frame, and traction to the head is applied to overcome muscle spasm; traction to the lower extremities is applied when the dorsal and lumbar regions are involved. The frame may be curved at the level of the disease process, especially if in the dorsal region. To enforce hyperextension of the spine, as described in the chapter on Apparatus, pads of felt may be inserted beneath the angular deformity and gradually increased as the deformity of the spine is corrected. In young children, it is always necessary to apply canvas strappings or an apron to retain the child in the recumbent position, or the frame described by Carrell may be used and is more effective as it allows exposure for heliotherapy. Ambulatory measures are indicated in young children when the process is arrested, or in rare instances, when recumbency is not well borne. In older children, above seven years of age, ambulatory treatment is indicated so soon as the acute stage has subsided. In infancy and early childhood, the contour of the body is almost that of an egg, and there are no bony prominences to which apparatus will conform; therefore, no appliance to the spine alone will secure sufficient fixation. Consequently, in children, ambulatory apparatus should extend from the occiput to the knees; otherwise, it is impossible to limit deformity, as the vertebrae are small, the spinal column short, and the body rotund. The author employs a modification of the Taylor spinal brace, extending from the occiput above to the knees below, and it is surprising how well children can walk without motion being permitted in the hips. This apparatus is indicated when any portion of the spine, except the cervical and dorsal above the eighth dorsal vertebra, is invaded. But when the process is above the eighth dorsal vertebra, the head must be supported by a head piece supporting the chin and occiput, which is attached to the back bars in order to transmit the weight from the spine to the pelvis. When the process is below the ninth dorsal vertebra, the brace extends above to the head, which is held in moderate extension, but not supported as in the cervical region, and below to both thighs just above the knee joint to permit full flexion of that joint. In the cervical spine, the Thomas collar or similar apparatus may at times be substituted in the convalescent stage. The Thomas collar is a round leather collar, stuffed with sawdust, of sufficient dimension to support the chin and occiput on the clavicles and shoulders. In older children and adults, ambulatory apparatus does not need to be so extensive as in children.

The Taylor spinal brace is sufficient for all lesions in the dorsal and lumbar spine below the level of the eighth dorsal vertebra. When the disease process is above the sixth dorsal vertebra, a head support must be attached to the spinal brace. Regardless of the treatment selected heliotherapy should be routinely employed.

Operative Treatment.—Operative measures for the purpose of inducing internal fixation or ankylosis are ideally adapted to the spine, as fusion may be accomplished without invading the diseased area, except in those rare instances where the laminae and spinous processes have been involved by continuity. The procedure is entirely extra-articular, the object being to fuse the posterior arches of the vertebral column, the principle of which is illustrated by the methods of Albee and Hibbs. The Albee operation is attended by less shock, and may be accomplished in a much shorter space of time, as an assistant may remove the graft while the surgeon prepares the graft bed. Under no circumstances should stress or tension be made upon any part of an autogenous transplant, as there will always be a dissolution of the graft at the point of stress, thus defeating the purpose of the operation. On account of the nature of the bone in early childhood transplants are rarely successful. Fusion of the spine by the Hibbs procedure is also difficult in young children. Therefore, the chance of arresting the disease by operation in children is materially less than in adults. The Hibbs procedure has the advantage of decreasing external deformity and can be employed regardless of the degree of deformity. In well-selected cases fusion may be accomplished by either method. In those cases with extreme kyphos, the author employs the Hibbs procedure with the addition of the Delagénierè osteoperiosteal graft from the tibia. When observed in the early stage, before deformity has occurred, and when the prospects of a successful operation are better, the Albee operation is recommended.

Albee's Technic.—Through a curved incision the spinous processes are exposed, the supraspinous and intraspinous ligaments are split longitudinally, and the spinous processes are split in half nearly down to the neural arches; one half of each spinous process is fractured completely at its base and displaced laterally. The graft bed thus prepared presents a median longitudinal gutter into which a graft of sufficient length, which has been removed from the tibia by a motor saw, is placed. The graft is immobilized by sutures of kangaroo tendon or catgut, and the supraspinous ligament, muscles, and fascia are sutured over this. The graft should be sufficiently long to include at least two vertebrae above and two below the site of the affected ver-

tebra. After the wound is closed, the patient is placed on a Bradford frame, or in a cast for six or eight weeks.

Hibbs' Technic.—A longitudinal incision is made directly over the spinous processes through the skin, supraspinous ligament, and periosteum, to the tips of the spinous processes. The periosteum is split over both the upper and lower borders of the spinous processes and the laminae, and stripped back to the base of the transverse processes.

Fig. 148.—Technic of Albee's operation for fusion of spine.

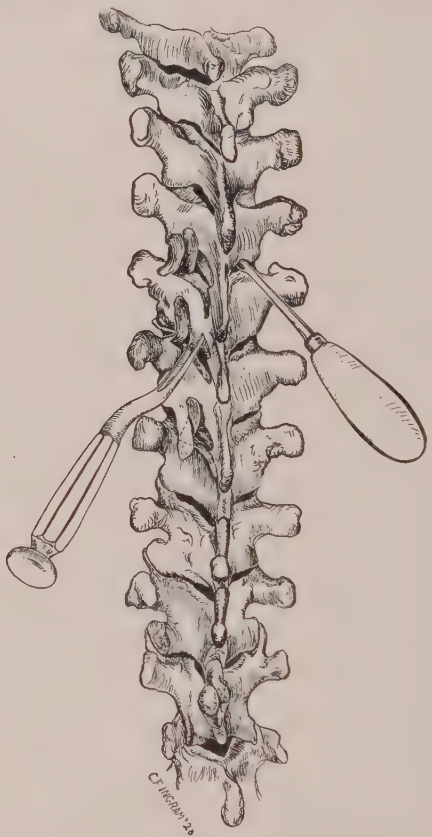


Fig. 149.—Technic of Hibbs' operation for fusion of spine.

The operation aims to induce fusion at five distinct points—the laminae and articular processes on each side and the spinous processes in the midline. The joints of the articular processes are destroyed by cureting out their cartilaginous surfaces, proceeding systematically from one vertebra to another. The small bone flaps are raised from each laminae with a suitable bone gouge, one turned upward and one downward, so as to make contact with the laminae above and below. The spinous

processes are broken down using a specially constructed bone forceps so that the tip of the process comes in contact with the bone of the vertebra below. The entire periosteal sheath is brought together and sutured and the subcutaneous tissues and skin closed. The spine is immobilized in a previously prepared and bivalved cast for a period of eight weeks, after which a brace is employed until fusion is solid and symptoms have entirely subsided, which usually requires about one year.

Tuberculosis of the Shoulder

Tuberculosis of the shoulder joint is rare, especially in children. The process begins most frequently in the head of the humerus. Inability to abduct fully is the first abnormality noticed followed by gradual restriction in all movements until the range is limited to a few degrees. Pain is severe and referred, radiating down the arm, and if there is distention of the joint, local pain may also be present. In the early stage induration of the capsule may be detected on palpation and swelling is apparent. Muscular spasm, which can not always be differentiated from contracted soft structures, is present. Atrophy, apparent below the deltoid muscle, is obscured above by periarticular and intra-articular exudates.

Fig. 150.—Tuberculosis of shoulder with erosion of head of humerus.

Treatment.—In children the treatment is conservative. A special splint is employed to maintain abduction of about 135 degrees, with slight flexion and internal rotation. As the process is often extra-articular in the head of the humerus, the diseased area may sometimes be excised. In adults a fusion operation is indicated and may be accomplished by the Steindler method or by an osteoperiosteal graft.

Steindler Technic.—The patient lies upon the sound side with the body supported by sand bags. The operator faces the back of the patient and one of the assistants is placed on the opposite side in order to exert a downward pull upon the extremity during the operation.

A curved incision is made over the shoulder and the flap thus outlined is turned upward to expose the edge of the acromion process. The middle portion of the deltoid muscle is defined, or if it has degenerated into a connective tissue sheet, one defines what would correspond to this portion of the deltoid muscle. The edges of this portion are incised longitudinally from the insertion of the muscle upward to the acromion process. The extremity of the acromion process is chiseled through and the muscle flap, with the end of the acromion, is reflected downward. The elongated capsule is incised by a longitudinal incision to which transverse cuts are added at the glenoid fossa so that the

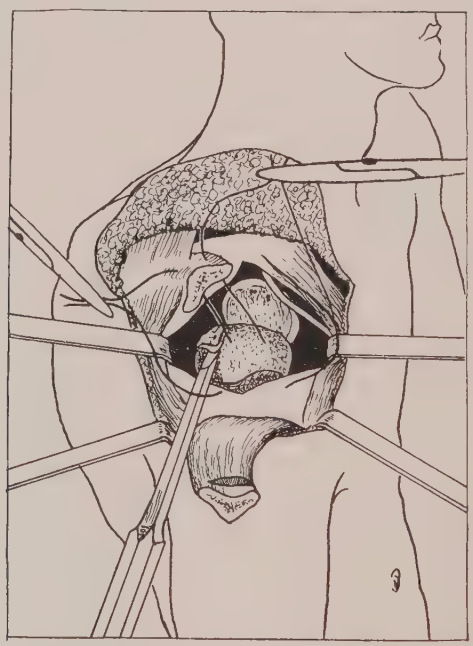


Fig. 151.—Technic for fusion of shoulder for tuberculosis (Steindler).

entire anterior half of the sac is open. As the arm is pulled downward by one of the assistants, the whole of the glenoid fossa and all of the humerus come into view. Just anteriorly to the incision the long tendon of the biceps muscle from the supraglenoid tubercle is seen as it passes through the joint. All cartilage is removed from the glenoid cavity and from the head of the humerus. The two freshened articular surfaces are apposed with the arm in the position of abduction. The head of the humerus is drilled in two places and the exposed portion of the acromion is also perforated by two drill holes. Through these

holes in the head of the humerus and in the acromion process two strong catgut sutures are passed. By suturing the capsule in a transverse direction, the slack of the elongated sac is taken up. The sutures are now tied with the arm held in abduction and forward flexion, a position which is to be carefully maintained until the arm and shoulder rest safely in the plaster cast. The bone muscle flap is sutured posteriorly to the spine of the scapula to serve as a hammock against which the head of the humerus rests and which counteracts the tendency of the head to be displaced backward. The wound is closed in layers and a plaster cast is applied which encases the arm and forearm and reaches from the shoulder to the hips. The cast is worn for three months, is then removed and a splint is applied maintaining the arm in the same position. Not until active elevation of the entire extremity is possible may the angle of the splint be changed and the arm brought down, and in the course of three or four months the splint may be entirely discarded.

Osteoperiosteal Graft.—Extra-articular fusion of the shoulder may be accomplished by employing an osteoperiosteal graft. An incision is made on the posterior aspect of the joint, exposing the spine of the scapula and the upper 3 or 4 inches of the shaft of the humerus. A surface on each bone is denuded and an osteoperiosteal graft from the tibia placed in direct contact with both bones. The wound is closed and the arm immobilized in a plaster-of-paris cast until union is solid.

Tuberculosis of the Elbow

The process originates more often in the humerus, but may arise in the radius or ulna. In adults, the synovial type of tuberculosis is more frequently seen in the elbow than in other joints. There is a gradual decrease in range of motion, and the joint in the later stages is fixed by muscular spasm at an angle of about 130 degrees. The bony prominences are obscured by fusiform swelling which becomes exaggerated by the atrophy of the arm and forearm. Fluctuation is often apparent, but is in reality usually due to edema of the synovial membrane and periarticular structures. Local heat, as in the knee, is increased, pain is often of an acute and throbbing character, and tenderness is constant. Abscess formation and secondary infection are frequent, but are not such serious complications as abscess in the spine and hip.

Treatment.—Tuberculosis of the elbow in children is treated by conservative measures. The forearm should be immobilized at right angle with the arm in the midposition between pronation and supina-

tion. In adults two procedures may be attempted, one extra-articular fusion, and the other excision; arthrodesis is employed when the process is observed in the very early stage.

Arthrodesis.—A posterior incision 6 inches in length is made, passing through the triceps muscle down to the humerus, and extending below to the posterior surface of the ulna. The lower third of the posterior surface of the humerus and the olecranon process of the ulna are exposed, and bone shavings are chiseled from the cortex. While this procedure is in progress an osteoperiosteal graft of suitable

Fig. 152.—Tuberculosis of elbow with erosion of articular surfaces.

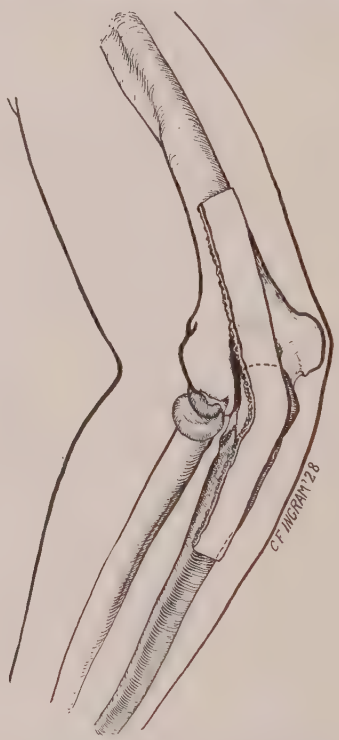


Fig. 153.—Technic of extra-articular fusion of elbow using osteoperiosteal graft.

dimension is removed from the tibia, the bony surface of which is placed in close proximity to the denuded surfaces of the humerus and olecranon process. Close approximation is maintained by sutures or autogenous bone nails. This procedure is very rarely employed, as extensive destruction is usually present when the process is first observed; also, osseous fusion may not be secured in sufficient time to prevent extension of the tuberculous process.

Excision of the elbow is indicated when the destruction is extensive, and many surgeons perform excision in all adults with tuberculosis of

the elbow as soon as the diagnosis is made. An external lateral incision 6 inches in length is made over the posterior aspect of the elbow, extending from 4 inches above to 2 inches below the joint. The superficial and deep fascias are exposed, after which an incision is made through the triceps muscle to the humerus and through the posterior capsule to the elbow joint to about 1 inch below the head of the radius. The periosteum and soft structures are peeled from the lower extremity of the humerus with a periosteal elevator; the expanded lower extremity of the humerus just above the condyles is excised. The ulna and radius are excised just below the level of the head of the radius. If too much bone is removed, a loose flail joint will result. The synovial membrane, all hypertrophied and diseased tissue, and the investing scar tissue of all sinuses are excised. The wound is then closed and

Fig. 154.—Elbow after excision for tuberculosis.

the limb placed in a right angle splint. The results are satisfactory in a large percentage, though a rather unstable joint is to be expected; however, by muscular education and active use, a very serviceable member is conserved.

Tuberculosis of the Wrist

Tuberculosis of the wrist may begin in the lower extremity of the radius or in one of the carpal bones. The onset is insidious with swelling and slight limitation of motion. As the capsule is not resistant, extensive exudates may be present within the joint without producing tension and severe pain. There is a tendency to flexion and forward subluxation as the disintegration progresses.

Treatment.—Tuberculosis of the wrist, like that of the shoulder, is rare in children, but when observed, the joint should be held in dorsiflexion by suitable apparatus until the process is arrested. In adults both excision and fusion are employed; the results of the excision

operation are not usually very satisfactory, because, even if there is no recurrence of the disease, the wrist is somewhat loose and flail and may require the constant use of apparatus. When the joint is fused, the chance of recurrence is lessened, although an ankylosed wrist is undesirable.

Arthrodesis.—A posterior external incision is made over the radius, from 3 inches above to 2 inches below the wrist joint. Dissection is made between the tendons of the extensor digitorum communis and the extensor pollicis longus to the posterior surface of the radius and the wrist, thus exposing the lower extremity of the radius. All detritus is removed from the joint, and if extensive disintegration has not

Fig. 155.—Tuberculosis of wrist with osteoporosis, destruction of carpal bones and increased density of soft tissues.

taken place and the consistency of the carpus will permit, the articular cartilage is removed so as to approximate the bony surfaces. The posterior surfaces of the radius, carpus, and second, third, and fourth metacarpal bones are denuded. An osteoperiosteal graft is excised from the tibia, placed in close approximation to the denuded surfaces of the radius, carpal and metacarpal bones, and fixed by sutures or autogenous bone nails. The wound is closed and the wrist placed in a plaster cast in the extended position. The cast extends from the metacarpophalangeal joints to above the elbow. The fingers must remain free with full action of the metacarpophalangeal joints. At

the end of eight weeks the plaster cast is changed and at the same time a plaster model is made for a leather corset which will extend from the metacarpophalangeal joints to just below the elbow. The second cast extends only to the elbow, and is removed in two to four weeks, when the leather brace, which is reinforced with steel, is applied. Apparatus is used continuously until there is solid osseous fusion.

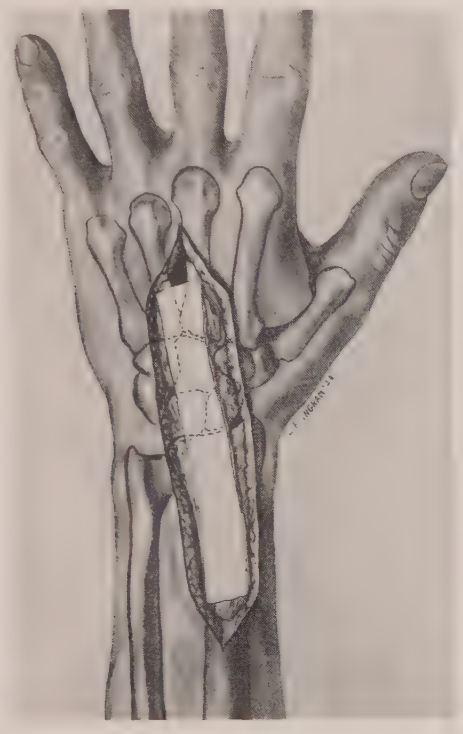


Fig. 156.—Technic of fusion of wrist using osteoperiosteal graft.

Excision of the wrist may be accomplished through a similar incision. The lower extremities of the radius and ulna and the entire carpus are removed, after which fixation is employed in the same manner as in fusion. Motion may be permitted in two to four months.

Tuberculosis of the Hand

Tuberculosis of the metacarpal bones and phalanges, like tuberculosis of the bones of the foot, is known as spina ventosa. The condition is very rare and is characterized by gradual onset of pain, swelling and induration about the affected bone. When the process is confined to one bone, resection may be possible.

The conservative treatment consists of fixation and heliotherapy.

BIBLIOGRAPHY

Albee, Fred. H.: Orthopedic Reconstruction Surgery, Philadelphia, W. B. Saunders Co., 1919, pp. 100, 222.

Brackett, E. G.: A Study of the Different Approaches to the Hip-Joint, with Special Reference to the Operations for Curved Trochanteric Osteotomy and for Arthrodesis, Boston Med. and Surg. Jour., 166:235, 1912.

Campbell, Willis C.: An Operation for Extra-Articular Fusion of the Sacro-Iliac Joint, Surg., Gynec. and Obst., 45:218, 1927.

Cobbett, Louis: Type of Tubercle Bacillus Commonly Present in Tuberculous Lesions in Bones and Joints, Brit. Med. Jour., 1:626, 1928.

Fraser, John: The Relative Presence of Human and Bovine Types of Tubercle Bacilli in Bone and Joint Tuberculosis Occurring in Children, Jour. Exper. Med., 16:432, 1912.

Gaenslen, F. I.: Sacro-Iliac Arthrodesis—Indications, Author's Technic and End-Results, Jour. Amer. Med. Assoc., 89:2031, December, 1927.

Haas, J.: Extra-artikulare Ankylosierung der Hufte, Zentralbl. f. Chir., 49:1466, October 7, 1922.

Hibbs, R. A.: An Operation for Stiffening the Knee-Joint, Ann. Surg., 53:406, 1911.

Hibbs, R. A.: A Report of Fifty-Nine Cases of Scoliosis Treated by the Fusion Operation, Jour. Bone and Joint Surg., 6:3, January, 1924.

Hibbs, R. A.: A Preliminary Report of Twenty Cases of Hip-Joint Tuberculosis Treated by an Operation Devised to Eliminate Motion by Fusing the Joint, Jour. Bone and Joint Surg., 8:522, 1926.

Rollier, Auguste: Heliotherapy: With Special Consideration of Surgical Tuberculosis, ed. 2, New York, Oxford Univ. Press, 1927.

Smith-Petersen, N. M., and Rogers, William A.: End-Result Study of Arthrodesis of the Sacro-iliac Joint for Arthritis—Traumatic and Non-traumatic, Jour. Bone and Joint Surg., 8:118, 1926.

Steindler, A.: A Textbook of Operative Orthopedics, New York, D. Appleton and Co., 1925, p. 268.

CHAPTER VII

ANKYLOSIS

Ankylosis may be defined as the restriction of the normal range of motion in a joint, and may be caused by various pathologic processes within the joint or periarticular tissues. The etiologic factors which cause ankylosis may be enumerated as follows: (1) acute infectious arthritis; (2) pyogenic infections of the soft structures which may be associated with an osteomyelitis; (3) trauma with laceration of the soft tissues, with and without pyogenic infection; (4) simple fractures associated with extensive laceration of the soft tissues; (5) penetrating wounds from without, complicated by infection, as gunshot wounds; (6) penetrating wounds from within, with and without infection, as compound fractures; (7) comminuted fractures terminating in irregularities which block joint motion; and (8) low-grade infections, as tuberculosis, syphilis, and the atrophic and hypertrophic types of arthritis. In the first seven of these etiologic factors, ankylosis or restricted motion is a sequela after the process is no longer active. In the low-grade infections, restricted motion occurs as a complication while the original etiologic process is still active, and ankylosis, therefore, is of secondary importance and not always amenable to treatment until the pathologic process has subsided.

Ankylosis may be classified as: (1) extra-articular restriction due to contracture of the soft tissues; (2) extra-articular block by abnormal bony process; (3) intra-articular incongruities or abnormalities of the articular surfaces; (4) intra-articular ankylosis, which may be either fibrous or osseous in type. Thus, ankylosis may be extra-articular or intra-articular; the extra-articular, or periarticular, type may be caused by contractures of the soft structures or by extra-articular bone block. The intra-articular type may be due to fibrous or osseous union between the articular surfaces or to incongruities within the joint. As a matter of fact, fibrous and osseous ankyloses are different stages of the same pathologic process, and differ merely in degree and not in kind. Osseous fusion between the joint surfaces is termed "true ankylosis"; false ankylosis is rigidity of the joint due to contracture of the surrounding tissues.

EXTRA-ARTICULAR ANKYLOSIS

Periarticular restriction of motion, or extra-articular ankylosis, is the restriction of motion by contracted extra-articular adhesions of the fascias, tendons, muscles, and ligaments.

Pathology.—Periarticular ankylosis is usually the result of some inflammatory process involving the soft tissues about the joint which is rendered immovable by a loss in the normal elasticity of the extra-articular structures. This is often caused by cellulitis involving the soft parts associated with the etiologic factors mentioned previously, though minor changes in the joint, as adhesions of the articular surfaces are frequently associated when the destructive process has been extensive. In periarticular ankylosis there are fibrous adhesions with contracture of the soft parts. There may be every evidence of a former infection involving the muscles, capsules, tendons, and fascias, demonstrated by extensive scar tissue, uniting the soft structures to each other or to the bone by dense fibrous adhesions. Even the skin itself may be adherent en masse to the soft structures or directly to the bone as a result of infectious processes and tissue destruction.

Symptoms and Diagnosis.—Motion may be free and normal in certain directions, but restricted in others, or in any one direction, and may vary in degree from scarcely perceptible movement to almost normal range. Extra-articular restriction may occur with the member in the most useful position for functional use; or, with malposition, when no function is possible, though a considerable range of motion may be present. The affected joint may be without symptoms, or may be irritated, painful, swollen and tender from attempts to function in malposition with uneven distribution of the weight. The natural disability from restricted motion will, of course, be present, and there may be crepitus on motion. Luxations or subluxations of joints are not infrequent complications. The diagnosis must be made from the history of a previously active pathologic process and an examination which clearly demonstrates the restricted function by extra-articular contractions. The roentgenogram usually shows a perfectly normal joint when the extra-articular process has not been complicated by extensive intra-articular lesions.

Treatment.—The treatment of extra-articular ankylosis depends upon the duration of the affection and the tensile strength of the contracted tissues. If efficient mechanical treatment has been instituted during the active process, the joint will be fixed or restricted in the most useful position. Active use will be possible early and restoration of function will be more rapid. Unfortunately a large percentage of

cases do not receive efficient treatment and when examined by the orthopedic surgeon, the joint is found to be maintained in malposition. If contracture is recent and of mild degree, conservative measures are indicated; otherwise, operative procedures are necessary.

Nonoperative Treatment.—When the contracture is of short duration, gradual correction of malposition which materially aids in inducing active and passive movements, may be secured by special apparatus devised to meet the requirements of each joint. When motion is restricted with the limb in the most useful position, function may be materially increased by physiologic activity—walking will often increase the range of motion in an ankle restricted in good position. Physiotherapy, described in treatment following operative procedures, is used as a method of conservative treatment.

Operative Treatment.—When contractures have existed for a long time or when completely organized, no increase of function may be possible by conservative measures. In such cases, the operative procedure must be so planned that all strictures restricting motion may be elongated, but without danger of impairing the future function of such structures. The plastic rearrangement of these structures must permit free, easy, and unhampered joint action. Brisement forcé should be used with the greatest caution as fractures may be induced. Rarely should more than 10 degrees of motion be induced by forcible manipulation on each occasion, as a violent reaction may ensue which will defeat the purpose of the procedure. After correction by either conservative or operative treatment, function must be cultivated by active use, with specially directed exercises to restore normal function to the affected muscles or parts. Physiotherapy, consisting of massage, diathermy, dry heat, and active and passive movements, is a most valuable measure, and should be employed not only when the deformity can be conservatively corrected, but as a treatment to increase function following surgical procedures. Active and passive movements should be carried out by the patient at specified periods daily, the joint being carried through the widest possible range of motion in all directions. The number of times the movement is repeated should be gradually increased. Passive motion is aided by means of a system of sling and pulleys adapted to the individual joint. For example, in the knee, a Sinclair modification of the Thomas splint, or a simple block and tackle with sling and pulley, described in the after-treatment of arthroplasty, are very effective. When physiotherapy is not available, active and passive movements by the patient are beneficial and should be employed.

The Ankle.—In periarticular contractures of the ankle the position is virtually always equinus associated with some degree of varus or valgus of the foot. When either varus or valgus is present correction may usually be accomplished by manipulation over a wedge-shaped block or by the use of an instrument, such as the Thomas wrench. Very rarely is it necessary to sever the peroneal tendons, but never the tibials. Operations on the bone, as tarsectomy for correction of varus or valgus, are seldom required. After correction of varus or valgus, or, when equinus is uncomplicated, the tendo achillis must be lengthened.

Tenotomy.—In infants and young children, the tendon may be lengthened by the subcutaneous method. The skin having been previously rendered aseptic, the parts are so held as to render the shortened tendon prominent. The skin over the tendon is punctured in such a manner that this incision and the one in the deeper parts shall not correspond when the parts are relaxed. The tenotome is carried flatwise beneath and close to the under surface of the tendon, the cutting edge is turned against the tendon which is divided by a slight sawing motion. The section is usually accomplished by an audible crackling and the extension of the contracted part. The tenotome is then turned flatwise and withdrawn, the operator compressing the wound to prevent bleeding.

In older patients an open operation is preferable because of the size of the tendon and the danger of nonunion. The patient is turned upon his side or abdomen and an incision from 3 to 6 inches in length, depending upon the degree of contracture, is made to the lateral aspect of the tendo achillis. The skin and subcutaneous tissues are retracted and the tendo achillis divided by a Z-shaped plastic incision from side to side; or, as the author prefers, from before backward, so as to preserve the width and contour of the tendon with a minimum exposure of the new surface. After division of the tendon, the ankle, as a rule, can be dorsiflexed by slight force. If correction can not then be made, there is contracture of the posterior capsule, which should be severed transversely, care being taken not to divide the flexor longus pollicis tendon which crosses the capsule obliquely from above downward and inward. This tendon may be retracted upward. After incision of the posterior capsule, dorsiflexion should be quite free. It is often impossible to close the posterior capsule, as a definite space usually remains after correction of the deformity. This space, however, is later filled in by fibrous tissue. The wound is closed in the routine manner. A splint or plaster cast is applied to the leg, extending from the toes to a point just below the knee, which holds the foot at a right angle to the leg.

After one week active and passive motion and physiotherapy are instituted. The splint or cast is removed for these exercises and after three weeks a brace with a stop-joint to prevent plantar flexion is applied. The brace is used for walking during the day, and the splint is worn at night until voluntary motion has returned to such an extent that the foot can be held in the overcorrected position. However, careful observation must be made even after removal of the brace, for should relapse occur due to contracture of scar tissue the apparatus should be reapplied until it is quite evident that there is no danger of recurrence.

The Knee.—Motion in the knee may be restricted either by contractures on the posterior surface, holding the knee in the flexed position; or, on the anterior surface, holding the knee in the extended position. The knee is more frequently held in flexion, which is often associated with subluxation and external rotation of the tibia. This position is due to the combined action of the hamstring tendons pulling the tibia backward, and the iliotibial band and biceps muscles attached to the head of the fibula rotating the leg outward.

Fig. 157.—Lengthening of tendo achillis by division in anteroposterior plane.

Treatment.—Flexion Contracture.—In mild contractures full correction can be made by apparatus, as described in Chapter III. In severe contractures partial correction can also be made by apparatus, thus reducing stress on the soft tissues, diminishing the extent of surgery, and lessening the tendency to obstruction of the arterial circulation by tension when the knee is suddenly extended. The operative procedure for correction of flexion deformity consists of severance of the hamstring tendons by an open incision and never by blind tenotomy. A 2-inch incision is made on the mesial aspect of the thigh to expose the semimembranosus and semitendinosus tendons, and on the lateral aspect to expose the biceps tendon. The tendons are lengthened by the Z-shaped plastic method. It is often necessary

to make a separate incision just above the knee on the lateral aspect to sever the iliotibial band. Rarely, the posterior capsule is contracted and must be divided transversely through a midline incision in the popliteal space, as described by Brackett and Osgood.

Dissection is made between the large vessels and nerves which lie upon the posterior capsule, but fortunately, this procedure is seldom necessary. Under no circumstances should complete extension be obtained and maintained under tension, as this may cause serious interference with the circulation or injury to the nerves. If, at the time of operation, the circulation is impaired, the surgeon should be satisfied with fixing the leg in partial extension and obtaining the full correction at a later date by gradual force or by manipulation under an anesthetic. After correction of flexion, a cast or splint is applied from toes to groin, holding the knee in full extension. As soon as the incision has healed, which is usually about ten days, active and passive motion with physiotherapy are instituted. Apparatus is not discarded until full extension can be maintained by the patient's own volition. At night the knee is held in full extension by a simple splint.

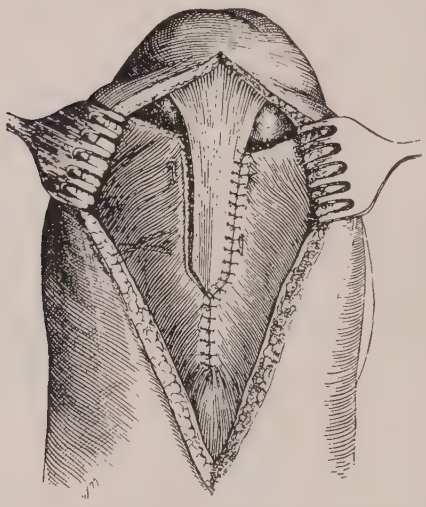


Fig. 158.—Technic of Bennett operation.

Extension Contracture.—Contraction of the quadriceps tendon and anterior structures may hold the knee in full extension with practically no motion. In this condition the quadriceps tendon should be lengthened by the Z-shaped plastic incision, or the method of Bennett, which is as follows:

Bennett Technic.—A straight incision is made on the anterior surface of the thigh reaching from the middle of the patella upward to the junction of the lower and middle thirds of the femur. The subcutaneous tissues and fascia are divided, the vasti muscles are bluntly dissected and the attachment of the rectus femoris to the former muscles and to the capsule of the knee joint is exposed. Of the four muscles of the quadriceps, the crureus or vastus intermedius is the deepest and it becomes easily tied down by adhesions to the anterior surface of the femur. If simple contracture without adhesions is present, the lengthening of the muscle is accomplished by the longitudinal incisions run-

ning to each side of the tendinous section of the rectus femoris. These parallel longitudinal incisions are then deepened to include the tendinous section of the vastus intermedius as well, and to separate both muscles from the vastus internus and externus. At the upper end these incisions are joined by a transverse incision. The tendon mass is further dissected from the underlying tissue until the tendon is completely detached. It is now possible to flex the knee fully, provided there is no interference with the motion of the joint itself, and in this position of flexion the knee is immobilized. When marked adhesions are present in the lower thigh, it is necessary, first, to free the vasti muscles from the anterior surface of the femur and then to continue with the dissection of the tendon. The results are most striking; within a few months full motion with perfect function is frequently restored in apparently stiff joints. Physiotherapy and other measures to induce function, after correction of extension contractures of the knee, are similar to those employed in the after-treatment of flexion contractures.

The author modifies the Bennett operation by using an internal incision so placed as to enter the knee joint, if necessary, for there may be associated with periarticular contracture very dense intra-articular adhesions, which must be excised after division of the tendon. Only very moderate force may be employed to induce flexion wthout danger of producing fractures, as the presence of osteoporosis in the extremity of the femur renders it very susceptible to trauma.

The Hip.—If, during the acute stage, the hip joint has been maintained in a straight line with the body, motion will be developed automatically by increased use of the part in walking and sitting, though, if the hip is flexed, proper function is impossible. If the contracted tissues have not become firmly organized, deformity may be corrected by traction in the line of deformity or by special apparatus after which a brace or cast must be applied to hold the thigh extended in line with the trunk and pelvis, and slightly abducted, thus maintaining the joint in the most useful position. In those in whom the contractures have become well organized, open surgery is often required. Subcutaneous tenotomy of the flexor tendons at their attachment to the anterior superior spinous process may be the only operative treatment necessary in mild contractures, or if fixed adduction is associated, the adductors may be severed subcutaneously with a tenotomy knife. If the contractures are severe, more extensive surgery is required, with division of the contracted tissues. Excessive force may tear or crush the tissues or cause fracture of the neck of the femur, and should, therefore, be avoided. In those with extreme flexion and abduction contractures, the author's operation of

transference of the crest of the ilium, as described in the chapter on Anterior Poliomyelitis is employed. When correction of the deformity is complete, the range of motion increases automatically by active use of the part in walking until the maximum function of the joint is regained.

The Shoulder.—Rarely, if ever, are open operative procedures indicated in periarticular contractures of the shoulder joint. In affections of this joint, the arm is fixed in adduction and internal rotation; abduction and external rotation being markedly limited. Such limitations are quite common following bursitis about the shoulder joint. In mild cases, active motion and physiotherapy may be sufficient. The treatment of severe contractures consists of forcible manipulation under anesthesia, though strong force is not necessary to break up extra-articular or intra-articular adhesions. It is seldom necessary in other joints to increase full range of motion by force, but the shoulder is a relaxed joint and adhesions are usually not very strong or resistant. The arm is forcibly abducted and rotated. After manipulation the joint should be held in extreme abduction and external rotation by a splint or cast for one week. Physiotherapy is then instituted and continued for an indefinite period.

The Elbow.—Extra-articular contractures are quite common in the elbow. Periarticular contraction holding the elbow in extension is usually due to contracture of the triceps muscle. The elbow is practically always contracted in flexion and, unless complicated by bone block or intra-articular adhesions, the contractures usually respond to simple active use. However, it is not infrequently observed that the biceps and brachialis anticus muscles are contracted, holding the joint firmly in flexion, which renders it amenable to relief only by operative procedures.

Treatment.—An incision is made over the anterolateral aspect of the elbow parallel to the margin of the biceps tendon, extending from about 2 inches above to 1 inch below the joint. The biceps and brachialis anticus tendons are exposed and dissection is carried to the anterior capsule of the joint, care being taken not to injure the musculocutaneous nerve which passes between the brachialis anticus and the biceps muscles, the incision being below and anterior to the radial nerve. The tendon of the biceps is severed obliquely and the brachialis anticus is stripped from its insertion into the coracoid process of the ulna. The anterior capsule may also require severance in order to obtain full extension. The wound is closed in routine manner. A cast is then applied and worn for three weeks to hold the limb in extension. Physiotherapy and active

and passive motion are instituted within four or five days and continued until normal function has returned.

Rotation of the forearm may be limited by contracture of the pronator radii teres muscle. Open separation of this muscle from its attachment to the upper third of the radius may be required. The procedure is as follows: An incision is made on the outer aspect between the extensor and flexor muscles, exposing the upper third of the radius. The attachment of the pronator radii teres muscle and the periosteum are stripped from the bone with a periosteal elevator. The forearm is forcibly supinated and a cast is applied to maintain this position. Rarely, severance of the interosseous membrane is necessary. The cast is worn for a period of about three weeks, after which a supinating forearm splint, described by Funston, is applied and worn until the forearm can be fully and voluntarily supinated.

The Wrist.—If a simple cock-up splint is applied during the course of a pathologic process in or about the wrist, usually no subsequent treatment is required; however, if the wrist is allowed to become palmar flexed or subluxated, correction of the deformity is necessary. Like the shoulder, the wrist is a lax joint and can usually be corrected by simple measures. Deformity may be overcome by gradual bending in a malleable splint, or by forcible manipulation under anesthesia, at which time the wrist is dorsified and a cock-up splint is applied. Open surgery is rarely indicated for extra-articular contraction of the wrist.

The Fingers.—Contracture of the fingers is not uncommon following tenosynovitis caused by various traumatic injuries and infections, or as a result or Volkmann's contracture. The contracture of the metacarpophalangeal joints is particularly resistant. Correction of flexion contractures of the fingers is brought about by a simple hand and finger splint made of galvanized iron. A tracing is made of the unaffected forearm and hand, after which the splint is cut to correspond with the tracing and covered with adhesive plaster. It is bent to conform to the contour of the affected hand and fingers. Strips of adhesive will hold the splint to each finger and to the wrist and forearm. The fingers and wrist are daily extended to a slight degree in the splint until full extension is secured. The banjo splint, though slightly more complicated, is also employed for the same purpose and is very effective. If the fingers are fixed in extension, the wire arc of the banjo splint is reversed so there may be a gradual pull in exactly the same manner upon the extended fingers until full flexion of the fingers and metacarpophalangeal joints is acquired. Rarely, is it necessary to do a posterior capsulotomy of the metacarpophalangeal joints by open incision.

INTRA-ARTICULAR ANKYLOSIS

Intra-articular ankylosis may be fibrous or osseous, and as previously stated, may result from the same causative agents. In fibrous ankylosis, the pathologic process has become arrested before the bone has been invaded to such an extent as to induce bony fusion. Osseous ankylosis results from a more virulent infection with a more extensive involvement of the bone and is usually a later stage than the fibrous.

Diagnosis.—The etiology of ankylosis has been previously discussed, but a differential diagnosis is necessary, as ankylosis caused by certain processes is more amenable to treatment than ankylosis caused by other processes. As the pathologic changes resulting from invasion by all pyogenic organisms are practically the same, it is often impossible to identify the organism in each individual case. Such differentiation, however, is not necessary, for the treatment of ankylosis caused by any of the pyogenic organisms is the same. An accurate distinction between ankylosis caused by pyogenic organisms and ankylosis induced by such low-grade infections as tuberculosis, is important. As ankylosis is more often observed a long while after the causative agent has either ceased to exist, or is in a dormant or inactive state, the clinical manifestations may not be of aid in establishing the etiology. Therefore, the diagnosis must often be made from the history and the roentgenogram, and in many instances from the roentgenogram alone.

The history of an acute infectious process with sudden invasion and high temperature will usually distinguish ankylosis of pyogenic origin. The etiologic agent is suggested when ankylosis follows or is a complication of an acute infectious disease; for example, an acute arthritis during the course or subsequent to pneumonia that runs an intensely septic course is suggestive of pneumococcus infection. A history of prolonged convalescence, with the joint remaining intensely painful and irritated for months is suggestive of infection by the gonococcus. In ankylosis, the result of an extensive osteomyelitis, there are usually multiple scars, adhesions to the bone, and evidence of old sinuses extending for a considerable distance along the shafts of the bones composing the joint. On examination by palpation, there will be massive hypertrophy of the shafts of the bones and often irregularity in contour of the bony surfaces. In ankylosis resulting from tuberculosis, atrophy of the affected member is usually more pronounced than in other pathologic processes. Osseous fusion is uncommon, and ankylosis is usually of the fibrous type. Motion is slight and often painful, and the patient may complain of joint strain. There is a history of insidious onset with

an indefinite course, often extending over several years. Syphilis seldom causes ankylosis, but may induce extensive destructive changes of the articular surfaces, causing pain from incongruity. There will be a history of an indefinite process, closely resembling tuberculosis, but the symptoms will be prolonged and without pain until destructive changes occur. The Wassermann test has been found a material aid in diagnosis, being positive in about 90 per cent of cases with bone and joint syphilis. In the low-grade infections and ostearthritic types of arthritis, there is a history of an afebrile inflammatory process running an indefinite course, often extending over months, resulting in painful and deformed joints after the process has subsided. Such pain is due to incongruity of the articular surfaces on slight motion. Solid osseous fusion occurs only in the late stage of such affections. In ankylosis following trauma, there will be a history of a severe injury followed by a period of disability. There may also be a change in contour of the extremity resulting from fractures. Bony ankylosis rarely follows trauma of the large joints, except the elbow.

Roentgenoscopy.—As the history and clinical findings may be obscure, the diagnosis of the cause of ankylosis often depends entirely upon the roentgenogram. In ankylosis from any cause, the roentgenogram determines the position and relation of the bones forming the articulation, loss in continuity and character of osseous structure. When not inhibited by massive hypertrophy of bone circumscribing the affected area, the roentgenogram will also demonstrate the pathology in the interior of the joint and adjacent thereto, as destructive areas, osteoporosis, cavities, and sequestra.

In ankylosis resulting from acute intra-articular pyogenic infection, the manifestations in bone are confined to the articular surfaces and to the subadjacent bone. At the end of three to six months after the subsidence of all symptoms, the joint line may be plainly visible, but narrower than normal; the extremities of the bones will show extensive osteoporosis with a very thin cortex. If the process ceases at this stage, a fibrous ankylosis may result, in which a line of cleavage will be permanently apparent; but if, as more frequently happens, the process does not subside at this stage, there is a gradual ossification until osseous fusion of the articular surface is complete, with an increase in density beneath the articular surfaces. Coincidentally with the intra-articular ossification, there is a gradual increase in structural density and condensation of the spongy bone with slight hypertrophy in the extremities of all bones comprising the joint. Also, there may be a slight proliferation of the periosteum for a considerable distance along the

shafts of the bones. Such hypertrophic changes cause the joint to stand out in marked contrast to the surrounding soft tissues.

In ankylosis resulting from acute infectious osteomyelitis, the etiologic factor may be the same pyogenic organisms which may cause acute infectious arthritis, but the process is diffused throughout the joint and the adjacent part of the shafts or the entire shafts of the bones comprising the articulation. There is massive hypertrophy of the extremities and shafts, with marked increase in density, which is characteristic. Even though the causative agents in osteomyelitis and arthritis are identical, the indications for operation in certain joints are totally different in the two conditions.

The roentgenogram rarely demonstrates osseous fusion in tuberculosis. There will be definite irregular dark areas of destruction and often destructive changes along the joint space, which are quite characteristic. There will also be atrophy of the shafts of the bones which may be smaller than the corresponding bones on the opposite side.

In low-grade infectious arthritis, osseous ankylosis is exceedingly rare. The process often terminates in extensive destructive changes with hypertrophy and erosion of the joint surfaces, though seldom solid fusion; ankylosis is usually fibrous. Differentiation may not be possible by the roentgenogram from acute pyogenic infections of a mild degree, or from a typical tuberculous joint, until exploration is made. The roentgenological appearance in syphilitic arthritis is often characteristic. The bones show hypertrophy with increased density; the periosteum and cortex may be thickened along the shafts of the bones adjacent to the joint. The articular surfaces may contain discrete punched-out areas and the bone underlying the articular cartilage may contain numerous opaque areas.

In progressive arthritis of the hypertrophic type, or osteo-arthritis, the roentgenogram may show extensive bone proliferation characterized by osteophytes. In low-grade progressive arthritis of infectious origin, the process is always polyarticular and characterized by atrophic changes by which the diagnosis can usually be made. When ankylosis is the result of trauma, the roentgenogram will demonstrate irregular callus formation and evidence of former fracture.

Treatment.—The treatment of intra-articular ankylosis is essentially surgical, the technic of which is known as arthroplasty.

ARTHROPLASTY

Various measures and procedures, as brisement forcé, arthrolysis and excision, with interposition of various inorganic materials, as metals,

wood, glass, etc., have been tried in attempts to mobilize ankylosed joints. The majority have been discarded as failures, and they are mentioned only because of their historical interest. No attempt will be made to describe all the methods used in the past, and the only treatment that will be considered is the modern method known as arthroplasty.

Arthroplasty consists in the reconstruction, not only of the osseous structure, but also of all the component parts of an articulation for the purpose of restoring both motion to the joint and function to the muscles, ligaments, tendons, fascias, and soft structures. The operation itself is only the first step in the reestablishment of function; a carefully planned after-treatment to reeducate the atrophic muscles is essential. An estimate of the results of arthroplasty should be expressed in terms of function and endurance and not in degrees of motion. Unless a durable, stable joint, which will stand average daily use, is restored, a joint ankylosed in the most useful position is far more serviceable. Arthroplasty must not be confused with excision, which is sometimes employed in ankylosis of certain nonweight-bearing joints, as the elbow and wrist. Excision is simply the wide resection of bone to induce pseudo-arthrosis, and should not be confused with arthroplasty which is a measure to restore function. The restoration of a joint with normal function and efficiency can not be expected. The joint is restored by functional adaptation, according to the well known physiologic principles of Wolff's law. The problem is obviously more difficult in the lower extremity than in the upper. In the lower extremity, not only must motion be restored, but the joint must withstand weight-bearing. Laxity or false motion is not desirable in any reconstructed joint; slight laxity is compatible with function in the upper extremity, though no undue laxity is permissible in the lower.

Indications and Contraindications.—In those joints where compensatory motion may be assured by adjacent joints, as in the shoulder and ankle, arthroplasty is rarely indicated or advisable. When the shoulder is ankylosed, function is compensated largely by an increase in motion between the scapula and chest wall. In ankylosis of the ankle, motion in the midtarsal joints is increased to some extent and may compensate for ankle motion. The three joints in which ankylosis most frequently occurs are the knee, hip, and elbow. Fortunately, these are most amenable to treatment by arthroplasty. Since every joint differs mechanically and anatomically, it is necessary to consider each a separate problem. No one procedure will meet the requirements of all cases. However, there are sufficient points in common to warrant a

general discussion before describing the treatment of ankylosis of the individual joints. The scope of the procedure and percentage of successful results increase with the experience of the surgeon, but care must be exercised in the selection of cases. Arthroplasty is rarely indicated except when ankylosis is the result of two causative agents: (*a*) acute pyogenic infection and (*b*) trauma. There are certain important factors in the treatment of ankylosis, enumerated below, which, if observed, may increase the probability of success.

1. All evidence of acute infection must have subsided for at least six months before the institution of operative procedures. This is a well-known surgical maxim.

2. Trauma uncomplicated by infection is seldom the cause of ankylosis. Arthroplasty is more often indicated for the relief of pain in those joints in which there is incongruity or blocking of motion caused by comminuted fractures.

3. In multiple ankyloses as a consequence of an acute pyogenic infection, arthroplasty is indicated and may result in restoration of motion in a number of joints in the same individual. However, the prognosis in any one joint, when there is multiple ankyloses, is much less favorable than when there is ankylosis of a single joint; ankylosis in other joints obviously inhibits cultivation of function in the reconstructed joint.

4. In ankylosis of a single joint caused by tuberculosis, arthroplasty or any radical measures within the joint are contraindicated. Undoubtedly, it might be possible to obtain excellent results in some instances, but the probability of relighting a latent tuberculous infection and the serious consequence thereof are well known and should be sufficient warning.

5. In those rare cases of multiple or bilateral ankyloses, due to tuberculosis of both hips or both knees, arthroplasty may be indicated, as the disability is so great that the risk of relighting the tuberculous infection is justifiable.

6. In progressive arthritis of a low-grade inflammatory type, as atrophic arthritis, arthroplasty may be attempted after the process has become quiescent or arrested. At present, the procedure in these affections is purely experimental and the prospects of restoring permanent function are slight.

7. The position in which ankylosis has occurred is an important factor. When ankylosis occurs in the most useful position for future function, the prognosis is much more favorable than when ankylosis occurs in malposition or luxation.

8. In those in whom there has been impairment of growth from obliteration of the epiphyses, or an excessive diminution in length from loss in continuity, caused by the destructive process, restoration of function would not be of sufficient advantage to justify the procedure.

9. Abnormal osseous structure, as demonstrated by the roentgenogram, may be an important factor in determining the prognosis and indications for arthroplasty. The prognosis is less favorable when the structure has been transformed for one or more inches adjacent to the articular surfaces. Old, dense, eburnated bone, extending for a considerable distance in the bones forming the articulation, is not a favorable soil for the production of a functional joint. Such a condition usually follows an extensive virulent osteomyelitis and results in low-grade bone tissue, which bears the same relation to normal bone that fibrous scar tissue bears to normal soft tissue. Not only is such dense bone poor material for the reconstruction of a joint, but the danger of relighting acute infection is grave. In the knee, dense bone will not form a satisfactory base for a new articulation and positively contraindicates arthroplasty. In other joints, such bone decreases the chances of success, but is not a contraindication.

10. The presence of osteoporosis or bone atrophy likewise interferes with the remodeling of the bones for the new articulation. When the position of the part will permit function of the member, active use with weight-bearing in the lower extremity should be encouraged for about six months before arthroplasty is considered. During this period the bone structure should be restored to normal. In those cases where malposition prevents functional use, osteoporosis persists indefinitely and the structure of the bone can only be restored to normal by special care in gradually inducing function and weight-bearing after correction of the deformity.

11. Normal cancellous bone should form the basis of the new articulation. Alterations in the internal structure of the bones, caused by a long period of disuse, are not favorable to the construction of a new joint. In such cases, there may be formation of a medulla or central canal completely traversing the joint and surrounded by cortex, which has been developed by the transformation of cancellous bone into dense bone. In this event, also, sufficient base may not be obtained to form a satisfactory joint and, further, the restoration of function to the muscles, which will have become commensurably atrophic, will be difficult.

12. The age at which arthroplasty may be attempted varies somewhat in the different joints. The most favorable age is between eigh-

teen and thirty, though the procedure is permissible and justifiable in many up to the age of forty-five years.

13. Arthroplasty is contraindicated in children, as the epiphyses may be traumatized at operation and growth arrested or distorted; further, it is impossible to secure the cooperation necessary to induce physiologic and functional adaptation in the development of a new joint.

14. The social status and occupation of the individual must be considered; arthroplasty should be employed as a selective measure, especially in the weight-bearing joints. A stiff joint in good position is more serviceable in strenuous occupations.

Technic.—The operation of arthroplasty is best performed in a bloodless field. The limb is elevated and an Esmarch bandage is applied from below upward. A tourniquet is then placed above the operative area and the Esmarch bandage removed. In the arm, as the danger of paralysis from prolonged pressure is greater, the Esmarch bandage, or a wide elastic bandage is used in preference to the ordinary tourniquet, being applied snugly by circular turns. A tourniquet may safely remain on an extremity for about one and one-half hours, which is usually more than ample time for completion of the operation. The technic of the operative procedure differs in the individual joints in accordance with their anatomy and function. It has been found most advantageous to construct a simple type of joint which will restore function, without attempting to reproduce the anatomical details of the normal joint. Artistically, conformation to the anatomical structure is desirable, but from a practical standpoint, such precision may complicate the procedure and actually decrease the chances of success. In some joints, as the hip, the normal contour is the simplest to reconstruct; in the knee, one large condyle at the lower extremity of the femur and one shallow concave tuberosity on the tibia will secure a hinge that meets all the requirements of function. When there has been so much structural change that reproduction of the desired type of joint is impossible, an atypical joint may be produced. By this means, motion may be mechanically restored in those directions which will be of greatest functional use to the individual. The procedure of reconstruction of a joint may be divided into four parts: (1) the plastic adjustment of the soft parts; (2) the reconstruction of the bone; (3) the interposition of material between the articular surfaces; (4) after-treatment.

Plastic Adjustment of the Soft Parts.—In planning the operation, the position in which ankylosis has occurred must be taken into consideration, as well as the relation of the articular surfaces, and the contractures of tendons, fascias, nerves, and vessels. Undue tension must

not be placed on the nerves and vessels in correcting malposition; the tendons, fascias, and capsules, when contracted, must be lengthened by plastic adjustment, to permit free function of the articulation. The object should be the rearrangement of all contracted soft tissues to comply with the demands of restoration of function. Active function will be reestablished earlier if all structures are conserved. No tissues should be dissected unnecessarily; no tendons should be divided until the bone has been severed, as often even very large tendons may be of sufficient length to permit a fair range of motion after all scar tissue has been removed.

Reconstruction of the Bone.—The fusion of the bone, whether osseous or fibrous, should be entirely severed under direct inspection. Great force should not be used in separating the articular surfaces as crushing of the surfaces and fractures may occur. The amount of bone removed varies in each joint and according to the different conditions found in the same joint. A sufficient amount should be excised to permit easy play of the joint on manual traction; under no circumstances, regardless of the contracture of the part, should excision be so extensive as to prevent the formation of an adequate foundation for satisfactory articulation. For example, should all the expanded lower extremity, with the condyles, be removed from the humerus, only the shaft would articulate with the bones of the forearm and a flail pseudarthrosis would result. This in reality would be an excision and not an arthroplasty. In multiple ankyloses, it is permissible to remove more bone than in ankylosis of a single joint. Motion should be insured, if possible, for the individual must endure many operations, and the possibility of recurrence is much greater.

Interposition of Tissue.—The necessity of interposing some material between the osseous surfaces is greater in some joints than in others, as the tendency to reunion of the articular surfaces varies in the different joints. Though it may be possible to restore function without the interposition of tissue, experience has proved that the dangers of recurrence of ankylosis are much less when some tissue has been interposed. The interposing material, despite the conclusions derived from animal experiments, may actually function as a synovial membrane and undoubtedly plays an important part in the restoration of function. Some investigators have described bursal sacs or small cysts formed between the articular surfaces after arthroplasty with the interposition of various materials, while others have found an absorption of such material.

Baer and Sudhoff have reported cases in which an examination of the joint has been made several years after arthroplasty. The author

has had occasion to incise 6 cases of arthroplasty of the knee. The capsule and periarticular structures were much increased in thickness, possibly to about 1 inch. A definite joint space about one half the capacity of the normal knee was found, which extended between the articular surfaces of the tibia and femur, well under the patella and quadriceps tendon. A few adhesions were found between the quadriceps tendon and the posterior wall of the cavity, but these did not interfere in any way with movement. A small amount of straw-colored joint fluid was observed; this was less than is found in a normal joint, but was sufficient for lubrication. The articular surfaces were smooth, glistening and regular, and covered with a dense layer of fibrous tissue resembling in every detail the free transplant of fascia lata which was

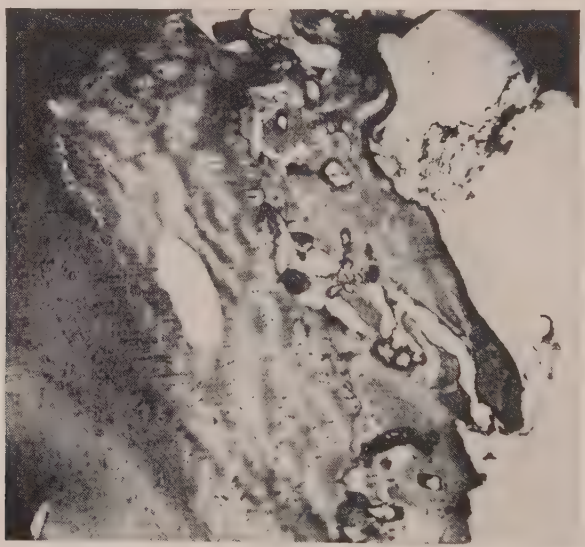


Fig. 159.—Photomicrograph of section from articular surface of femur following arthroplasty of knee in which 90 degrees motion was obtained. Note the layer of fascia lata adherent to an area of cartilaginous tissue which in turn is adherent to bone.

interposed at the original operation. A section of this fascia was removed from the lateral aspect of the joint, beneath which was found what appeared to be a cartilaginous and a fibrous layer. A section including these three layers was excised for microscopical examination. The specimen showed soft tissue composed of dense fibrous tissue and fibrocartilage, some areas showing the typical arrangement of fibrocartilage, others showing a clear homogeneous type of tissue. Both of these tissues were closely attached to the underlying normal-appearing bone.

From the findings, it is quite evident that a new functional joint is formed. In all probability, the investing membrane in time becomes absorbed at the point of greatest contact, being substituted throughout the joint by a different layer of cartilage. In fact, a complete new joint with lining membrane is formed, which, to some extent, differs from the normal in structure. The most interesting feature is the fact that apparently the fascia lata remains intact and acts as a permanent synovial membrane, which is contrary to all former deductions based upon animal experimentation. Also, the fact that interposition of tissues induces nonunion of fractures, or pseudarthrosis, is sufficient evidence to indicate that there should be insertion or some material between the joint surfaces in arthroplasty. Various organic and inorganic and specially prepared animal membranes have been employed in the past, but only those in common use at present will be considered.

Pedunculated Fascial Flap.—The pedunculated flap is secured by dissection of fascia in the vicinity of the joint. This method has been practically discarded as a routine, since it is often impossible to obtain a suitable transplant; the soft tissues adjacent to the joint may be involved by fibrosis due to the previous inflammatory attack, and therefore, may not be of desirable quality. More extensive dissection is required near the joint, increasing the extent of surgery and the possible area for subsequent formation of blood clots. Also, by the time the flap has been dissected sufficiently to place it within the joint, the pedicle is so small and the blood supply so impaired that the flap becomes practically a free transplant. Thus, the one advantage, which is nutrition to the flap, is lost. The pedicle flap is reserved for those cases in which a free fascia lata transplant can not be secured, or in multiple ankyloses, when the supply of fascia lata is exhausted; it is also used, when easily available, in certain special or unusual types of ankyloses, as in fusion between the patella and femur with free movement between the tibia and femur.

Transplants of Free Fat.—Transplants of free fat obtained from the abdomen, thigh, or elsewhere, are employed by a few surgeons, though the use of this substance has never been universally accepted.

Free Autogenous Transplants of Fascia Lata.—The majority of surgeons use the free fascia lata transplant routinely. A section is removed from the external aspect of the thigh, as a sheet of sufficient size to cover any desired area may always be obtained from this location, and this fascia is most suitable for transplantation. Most operators are content with the interposition of one layer, but the synovial membrane should be reproduced as fully as possible, and the author inter-

poses two layers of fascia lata between the articular surfaces. In transplanting, the fascia lata is reversed—the rough, superficial surface is placed in contact with the bone and the smooth, glistening side forms the interior of the articulation, thereby facilitating motion.

A histologic review of normal fascia lata excised at operation has been made by Prof. O. W. Hyman, of the University of Tennessee, who demonstrated that the arrangement of the fibers on the under surface was more regular and smooth than on the upper layers, and had the same appearance as tendon tissue; the outer fibers are not so compact and are covered with loose, areolar tissue, and will therefore adhere when in contact with raw surfaces of bone. Also, on account of its loose structure, this surface is more adaptable for vascularization by blood vessels than the more compact surface, which is more smooth and facilitates joint function.

Chromicized Pig Bladder.—This material is prepared and used by Baer who claims as advantages that the membrane remains in situ until the parts heal and, having performed its function, is absorbed; an additional incision for securing fascia is avoided, and the procedure is simplified. The disadvantage of chromicized pig bladder or other prepared membranes lies in the fact that foreign material of any nature invites infection. Any specially prepared membrane of sufficient dimension to be interposed between joint surfaces may of itself act as a foreign body and be extruded, just as may a very large suture of any material. Also, the preparation of this substance may be faulty, and if too much chromic acid is present, irritation and extrusion of the membrane may follow.

Fascial Transplants Preserved in Alcohol.—Animal fascial transplants were first described by Nageotte, who claimed that the fascia is inert and can be transplanted into living tissue, where it becomes incorporated as a living material. Koontz used this material in lieu of autogenous fascia lata in the repair of hernia. This fascia is removed from the thigh of an ox and preserved in 70 per cent alcoholic solution. Its use is advisable in multiple ankyloses when the supply of free fascia lata has become exhausted or when, for local reasons, it is not expedient to remove free fascia lata.

After-treatment.—The details of after-treatment must be adapted to the mechanics of the individual joints which will be discussed separately. Immediately after operation, the limb is immobilized in the most useful position, and kept absolutely fixed until the operative wound has entirely healed. Continuous traction is applied to the weight-bearing joints of the lower extremity. After ten to fourteen days mo-

tion is carefully instituted. Passive motion is induced by special apparatus, adapted to the requirements of each joint, and is under the direct control of the patient. At the same time, active motion is cultivated by the aid of the apparatus for passive motion. At first, fear of pain on motion reflexly inhibits voluntary contraction of the muscles. Only feeble voluntary contraction may be possible, but this is gradually cultivated until the joint can be moved by control of the patient. Unusual courage and fortitude, though thought by some to be essential in the after-treatment, are not required. If the necessary corrective measures are properly planned and carried out, patients do not suffer intensely; if not, such exercises are actually injurious, and are incompatible with the purposes of treatment. Motion must be cultivated, not forced.

The value of physiotherapy should not be underestimated. This measure should be employed daily whenever possible, as it is well known that the cultivation of active motion, unless directly under the control of an expert, is most difficult after disability of any joint. However, if such special service is not available, it is possible to restore excellent function by having the patient follow carefully well-planned constructive exercises. The cultivation of the musculature, weakened from disuse, must be continued long after a satisfactory range of voluntary motion has been secured. Too many patients are satisfied with a moderate range of voluntary motion and fail to cooperate in the complete restoration of musculature. There must be not only voluntary motion to a satisfactory range, but also an approach to normal power.

Motion must not be cultivated too rapidly. The best results are obtained when passive and active motion are developed at the same time. If passive motion proceeds too quickly for active motion, the atrophic bone may be softened and the weak ligaments elongated, with an increase in laxity of the joint and decrease in muscular control. Unless the musculature can be developed, passive motion in the reconstructed joint will be greater than active motion, resulting in instability and weakness. Physical examination of the joint must be made frequently and any abnormality, as increased tenderness, pain, or swelling must be noted, also the stamina of the ligaments and the musculature. Any evidence of inflammation requires immediate rest until all active symptoms subside, when treatment may be cautiously resumed. Any decrease in muscular power without inflammation is a danger sign and requires a very careful search for the cause; it usually indicates bone atrophy or stretching or elongation of ligaments with increased laxity. Roentgenograms should be made from time to time to determine the status of the osseous structure; should osteoporosis exist,

care should be taken to increase active function as rapidly as possible, but to limit intra-articular pressure. In the joints of the lower extremity no weight should be borne until the osteoporosis has disappeared and the bone structure approaches normal, when weight-bearing is gradually permitted. Physiotherapy is of material value when osteoporosis is present.

The patient must be under observation for at least one year. During the second year, more can be accomplished toward the restoration of normal power, as the exercises may be more strenuous. Special splints or apparatus are at times required for each joint, for the purpose of preventing false motion and too rapid an increase of movement in the normal direction, the danger of which has been previously described. Once active motion has been established through a range of as much as 30 degrees, there is no tendency to reankylosis and the range of motion is increased and not decreased. In those in whom only a few degrees of active motion is possible, recurrence of ankylosis is probable.

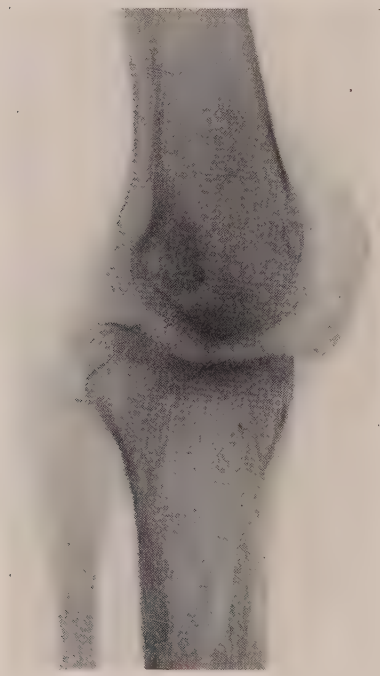


Fig. 160.—Proliferation of bone about margins of joint following arthroplasty.

Brisement forcé is very rarely required. In resistant cases motion may be increased under anesthesia by manipulation of not more than 10 degrees at any one time. Manipulations of more than this may induce a severe reaction with exudation and reorganization of inflammatory products, and the adhesions between the surfaces are increased. Under no circumstances should great force or pump-handle methods be employed, as there is danger of crushing the joint surfaces, inducing intra-articular irregularities, or even gross fractures, or tearing of the soft structures, ligaments, and tendons.

Arthroplasty of Special Joints

The technic of arthroplasty as applied to the various joints in which the procedure is indicated will now be considered. An osseous fusion of the ankle joint, shoulder, and wrist joint may be largely

compensated by motion in the adjacent joints, the scope of the procedure is limited; the technic, therefore, will be described only as applied to the knee, hip, elbow, and temporomaxillary joints.

Arthroplasty of the Knee

Restoration of function by arthroplasty and subsequent treatment is a more intricate problem in the knee than in other joints. This is due to the fact that the knee is the most complex articulation in the body and is dependent for stability upon ligamentous support on all four sides externally, as well as within the joint.

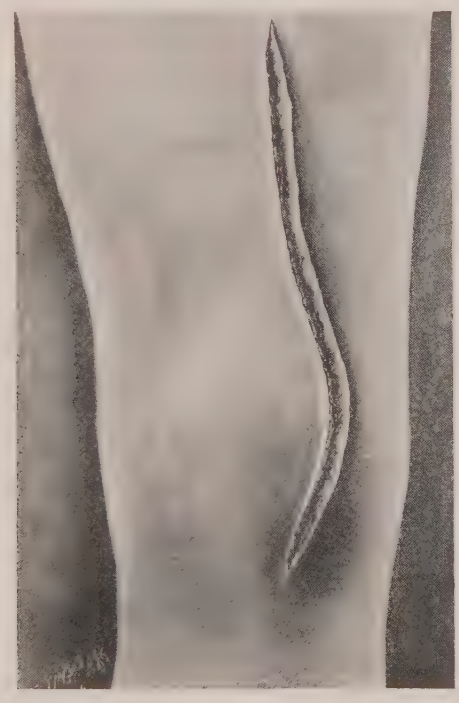


Fig. 161.—Incision to medial side of patella for arthroplasty of the knee.

Indications.—The indications and contraindications for arthroplasty have been described for the joints in general, but there are certain factors which must be especially considered before undertaking arthroplasty of the knee.

1. Position is an important factor. Ankylosis in full extension or not over 30 degrees flexion is more favorable for arthroplasty. Flexion contracture of over 80 degrees renders the result more uncertain.

2. Shortening of more than 3 inches from destruction of bone or

lack of growth contraindicates mobilization, as further excision of bone would be required and the slight improvement in function would not justify the procedure.

3. In large, obese patients, especially women, the musculature and ligamentous structures are always deficient. In this type of individual the ligaments should be conserved and great care should be taken to remove as little bone as possible in making the joint space, as a loose, flail joint is more likely to occur.

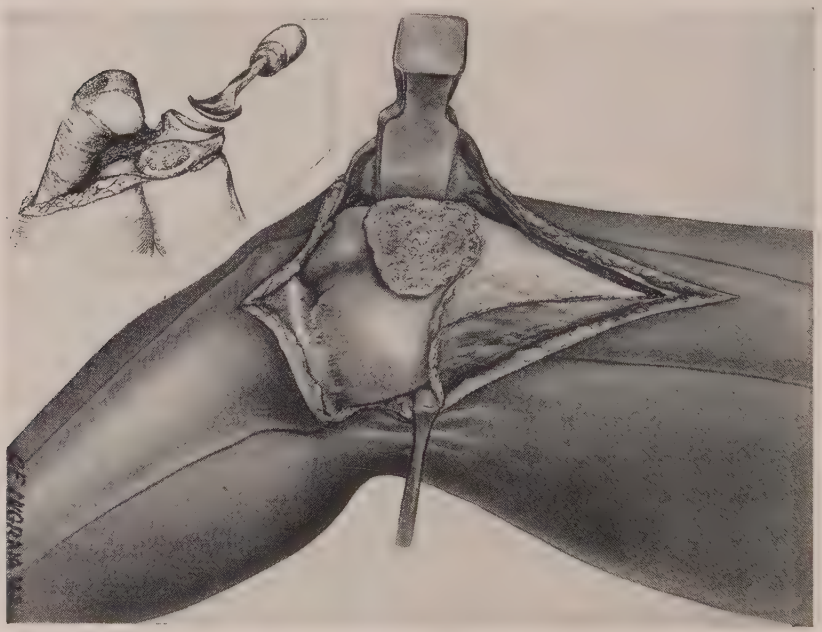


Fig. 162.—Formation of one large condyle on the lower extremity of femur and one shallow cavity on the upper extremity of the tibia. As much patella as possible is removed, and the patella retracted outward.

4. In the selection of cases the social and financial status of the patient must be taken into consideration. The procedure may be employed in all young adults whose occupation is not hazardous or in those who can be rehabilitated.

Technic.—In remodeling the knee joint, no routine technic is applicable to all cases; the procedure must be modified in conformity with the following conditions: (1) Distribution of ankylosis: (*a*) panankylosis, or complete bony fusion of the patella, femur and tibia, which is by far of most frequent occurrence; (*b*) fusion of patella and femur with tibiofemoral articulation apparently normal; (*c*) tibiofemoral

fusion with freely movable patella. (2) Position: (*a*) extension or slight flexion; (*b*) flexion with and without external rotation and valgus.

Panankylosis in Extension.—The incision is begun from 4 to 6 inches above the knee at the inner border of the quadriceps tendon and extended downward with slight convexity inward, parallel to the mesial

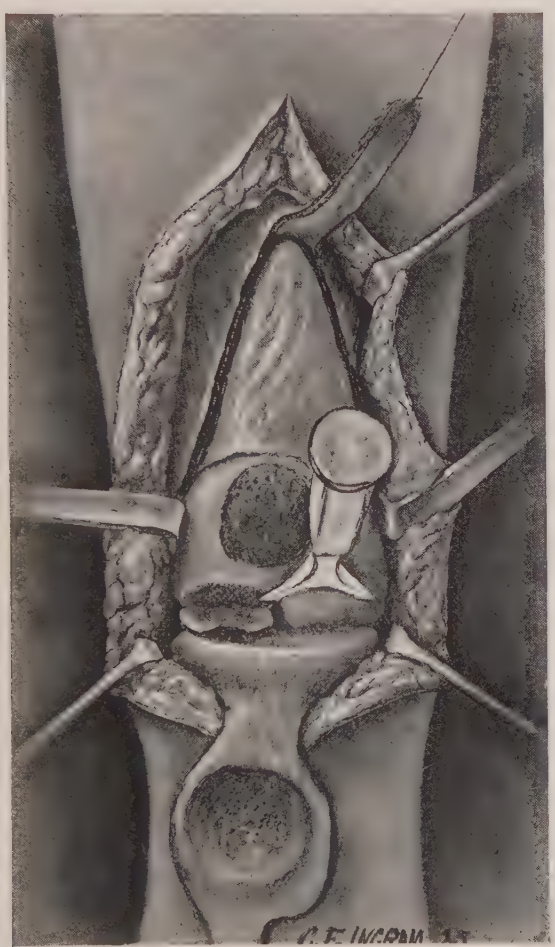


Fig. 163.—Anterior view of ankylosis in extension. The quadriceps tendon has been lengthened.

aspect of this tendon, terminating just below the attachment of the patellar tendon to the tibia. The skin, superficial and deep fascias are incised, after which the incision passes through the junction of the quadriceps tendon and the vastus internus muscle. Dissection is made to free the quadriceps tendon from the femur, and the bony union

between the patella and femur is divided with a chisel. All ligamentous structures are dissected subperiosteally from their attachment to the tibia and femur. If severely contracted, the quadriceps tendon may

Fig. 164.—Side view of area of attachment of fascia lata and pedunculated flap covering patella.

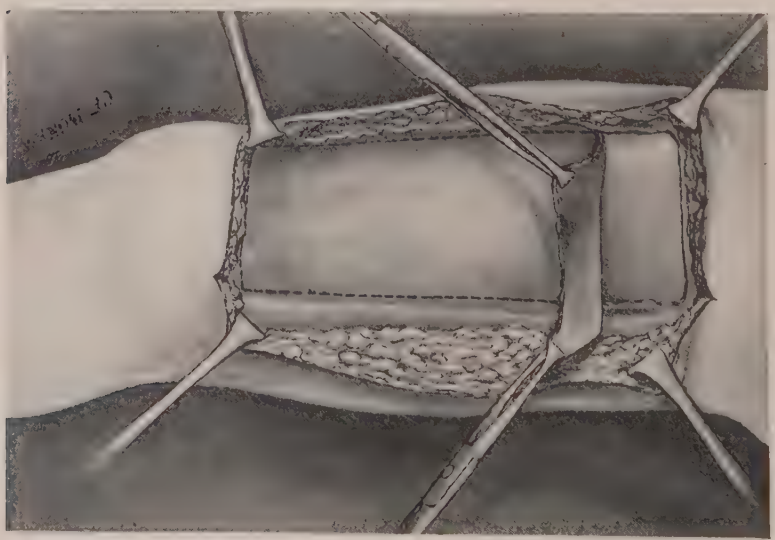


Fig. 165.—Technic of removal of fascia lata.

be lengthened by the Z-shaped plastic method; otherwise, it should be retracted outward. Until the tibiofemoral union is completely severed no attempt is made to flex forcibly, even in fibrous ankylosis, as fractures of the lower extremity of the femur are easily sustained and may be a serious complication. The knee is then fully flexed, giving free access to the articular surfaces of the tibia and femur. The posterior portions of the condyles of the femur are removed and the intercondylar notch thus obliterated. The lower extremity of the femur is now made convex from above downward and from before backward, forming one large condyle. Only such an amount of bone as is absolutely essential to reach cancellous bone is removed from the actual length of the femur, the larger portion of bone being taken from the posterior surfaces of the condyles. In this way, more space will be obtained and the length of the limb will be affected very slightly, if at all. The upper extremity of the tibia is excised as little as possible in order to reach healthy, spongy bone. With a wood-carver's chisel, this surface is made slightly concave from before backward, forming one large shallow cavity for articulation with the one condyle of the femur. After excision of the bone, there must be at least $\frac{1}{2}$-inch joint space when manual traction is made on the tibia. If this can not be demonstrated, more space can often be obtained by dissecting the periosteum posteriorly from the femur and tibia. No attempt is made to reproduce the spine of the tibia or the intercondylar notch of the femur, for there will be no crucial ligaments to prevent lateral displacement. If a new spine is formed, slight lateral displacement may easily occur when motion is instituted, bringing the irregular surfaces together with obvious mechanical damage. The lateral ligaments of the joint must be conserved in order to prevent instability, and care must be taken not to tear, stretch or sever these ligaments during the operation. The bony surfaces are next approximated and the alignment of the entire extremity observed. If varus or valgus is present, more bone is removed from each surface until a perfectly straight hinge is formed. Especial care should be taken not to produce valgus regardless of the position of the normal limb. Future weight-bearing must be direct and in a straight line.

Our attention is next directed to the patella, the posterior surface of which is removed, leaving only a thin layer of bone, or just enough to be consistent with tensile strength. The lateral margins are trimmed for $\frac{1}{4}$ inch to allow the fibers of the tendon to fold backward along the edge on to the posterior surface. A large rasp renders all surfaces smooth. All recesses are carefully searched and every particle of loose bone is removed. Just below the patella and on the posterior aspect

of the patellar tendon will be found a mass of fat, and, at times, remains of synovial membrane. This is severed at the junction with the tibia and dissected from below upward into a flap with a broad pedicle. The flap is stitched to the margin of the tendinous fibers, thus investing the posterior surface of the patella. This is an important step, for restoring mobility to the patella is the most difficult problem, and in those cases in which ankylosis recurs, adhesions begin between the patella and femur.

The contour of the new joint has now been completed and prepared for interposition of the membrane. As the former infection may have produced fibrosis in the soft tissues about the operative area of the affected limb, and in order to avoid excessive surgery to the one member, the transplant is best obtained from the opposite thigh. A long incision is made on the outer aspect of the thigh and a strip of fascia lata about 4 or 5 inches in width and 8 or 10 inches in length is removed. This membrane is placed over the lower 4 or 5 inches of the anterior aspect of the femur, covering the posterior wall of the anterior compartment of the joint. The membrane then passes from before backward over the newly formed condyle of the femur and is stitched posteriorly to the posterior capsule of the joint as high as possible; thence it is brought forward over the new articular surface to the tuberosity of the tibia, terminating on the anterior aspect of the tibia. All free edges are stitched with continuous suture of chromic catgut well over the margins of the joint. Thus, not only is there interposed two layers of fascia lata between the joint surfaces, but one layer is interposed between the quadriceps tendon and the tissues on the anterior surface of the femur. The pedicle flap interposes an additional layer between the patella and femur. The joint capsule, fascia, and skin are sutured in the routine manner, chromic catgut being used for the deep structures and dermal suture for the skin. The limb is placed in a Thomas splint with moderate traction.

Panankylosis in Flexion.—When ankylosis occurs in less than 120 degrees flexion, the anterior structures are redundant and the quadriceps tendon can always be retracted to the outer side. After removal of sufficient bone, if the posterior capsule is contracted and extension can not be obtained, stripping of the periosteum from the posterior surface of the femur above and the posterior surface of the tibia below, for 1 or 2 inches, will usually overcome the contracture and permit the knee to be completely extended, after which the procedure is concluded as previously described. Correction of rotation and valgus or subluxation can easily be made in remodeling the joint.

When ankylosis occurs in flexion of over 100 degrees, a two-stage operation is often advisable. The posterior portions of the condyles of the femur are excised through a posterolateral incision, thus removing about 1 inch of bone at the point of osseous contact to permit greater extension or reduce subluxation, if present. Further extension, if necessary, may be secured by severance of the hamstring tendons. A cast or fixation apparatus is applied with the limb extended as fully as possible, but without the slightest tension. If the necessary degree of correction can not be obtained at the first attempt, the cast is removed at the end of two weeks and gradual extension is acquired by special apparatus; otherwise, the cast is worn for six weeks. A brace is then applied and walking permitted for about two months before proceeding with arthroplasty.

Ankylosis of Patella and Femur.—In fusion between the patella and femur, with an apparently normal tibiofemoral articulation, the posterior surface of the quadriceps tendon is dissected free and union of the patella and femur is severed by a chisel. The interior of the joint is carefully inspected and division is made of the strong fibrous adhesions which are usually present. A broad sheet of fascia is dissected from the outer aspect of the same thigh and folded inward beneath the quadriceps tendon and the raw surface of the patella, the deep surface of this fold facing the patella and quadriceps. Should extensive scar tissue be present in the affected limb, a free fascial transplant is taken from the opposite thigh. Also, the pedicle flap from the fatty tissue just below the patella may be placed over the posterior surface of the patella.

Tibiofemoral Ankylosis with Freely Movable Patella.—Tibiofemoral fusion rarely occurs with a freely movable patella. This condition may be a sequela of acute infectious arthritis, but is more often the result of a virulent osteomyelitis extending for a considerable distance into the shafts of the tibia and femur, with direct bone infection across the joint space. The anterior portion of the joint may have been walled off by inflammatory exudate and protected from the infection in a manner similar to the phenomenon so frequently seen in the abdominal cavity. If the osteomyelitis has been extensive, the indication for arthroplasty is most questionable. Should arthroplasty be deemed advisable, the patellar tendon is retracted to the outer aspect, or, if contracted, is lengthened by the Z-shaped plastic method. The new joint is then remodeled, though the pedicle flap to the patella is omitted.

After-treatment.—Immediately after operation, moderate traction is applied and the limb is placed in a hinged Thomas knee splint with a

U-shaped bar passing anteriorly to the joint. The splint is locked in the extended position and no motion is permitted until the operative wound has entirely healed, which usually requires about ten days. At the end of that time, a rope is passed from the U-shaped bar of the splint to an overhead frame. A second rope is fastened to the lower cross bar of the Thomas splint and passed through a series of pulleys to the head of the bed. By adjusting these two ropes, any desired angle may be maintained and active and passive motion may be instituted by gravity under the direct control of the patient. The range of motion must not be increased too rapidly. At the end of thirty days, there should be not over 30 degrees passive motion in the knee, and at the end of sixty days, not more than 40 degrees. If motion is increased

Fig. 166.—Apparatus for active and passive motion following arthroplasty of the knee.

too rapidly, the atrophic ligaments may become overstretched. Furthermore, if osteoporosis occurs, which is a frequent complication, the soft bone may be compressed, increasing the joint space and causing irregularity, as well as adding to the danger of producing a loose, flail joint. Active motion should be increased synchronously with passive motion, and muscle function should be cultivated gradually until restored to an adequate degree. Complete extension is essential. Sixty to eighty degrees flexion gives the best function and a member which can be used practically for all purposes.

If the joint is stable at the end of six weeks, the splint is removed and walking is allowed in a brace with an adjustable joint at the knee to permit gradual increase of motion. If there is the slightest osteoporosis, a portion of the weight should be borne by a Thomas ring

added to the brace. Full weight-bearing should not be allowed until the structure of the bone is virtually normal and a fair degree of power has been developed in the quadriceps muscle. Extreme care must be given the reeducation of the extensor group of muscles and the flexors must also receive due attention. When the patient begins to walk, the knee should be diligently exercised until the maximum power has been restored.

Putti Technic.—The technic devised by Murphy has in recent years been further modified by Putti. An Esmarch bandage is applied to the leg, and a U-shaped incision is made with the base downward surrounding the patella. A piece of bone 3 by 4 cm. including the tibial tubercle and the insertion of the patellar tendon is removed. The patella is

Fig. 167.—Range of flexion following arthroplasty of knee.

Fig. 168.—Same as Fig. 167, showing complete extension.

detached from the femur and retracted to the inner side, exposing the ankylosed joint. The ankylosis is destroyed by beginning on the outer side and working inward, using special curved chisels of different shapes. The ends of the femur and tibia should be rounded preserving as much as possible of the transverse diameter of the condyles, but decreasing the sagittal diameter. The contour should approach that of the normal; the spine of the tibia should be made sharp and the intercondyloid groove deepened. Sufficient bone should be removed to permit the separation of the surfaces for 1 cm. The resected surfaces are smoothed with a file. A free transplant of fascia is used in preference to the pedunculated flap. It is better to have both resected surfaces covered, although one is sometimes enough. The excess thickness of the patella is removed. No additional interposition of fascia is made between the

patella and the femur. Before the skin is closed the tibial tubercle is replaced and fixed with a metal nail. In cases in which ankylosis is in full extension or slight flexion, it is difficult, even after resection, to

Fig. 169.—Ankylosis of knee. Anteroposterior view.

Fig. 170.—Same as Fig. 169. Lateral view.

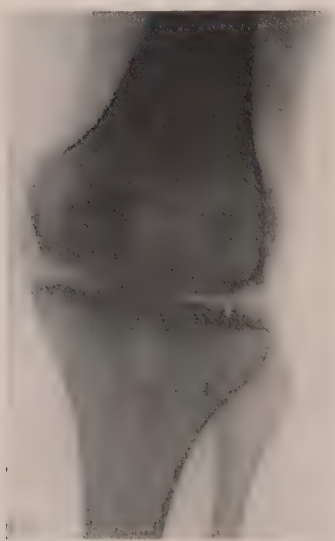


Fig. 171.—Knee after arthroplasty. Anteroposterior view.

Fig. 172.—Same as Fig. 171. Lateral view.

flex the joint. In such cases the quadriceps tendon is lengthened. The leg is immobilized in a plaster splint in a semiflexed position. Traction of 4 to 5 Kg. is applied for fifteen days. After the stitches are removed the leg is taken from the splint and active and passive motion begun with strap and pulleys suspended from an overhead frame. Walking is permitted with a brace at the end of one and one half months.

Arthroplasty of the Hip

The hip being a ball-and-socket joint does not depend so much upon the ligamentous support for stability as the other joints. Mechanically, therefore, it is ideal for arthroplasty, but clinically the results are not so good as in the knee. Ankylosis in the hip may be unilateral or bilateral. Bilateral ankylosis is observed far more frequently in the hip than in other joints, probably due to the fact that the hip is closer to the bifurcation of the aorta and the circulation carries the pyogenic organisms by a more direct route than to the peripheral joints. The hip is also more frequently involved in a polyarticular arthritis than any other joint. From an analysis of the author's records, bilateral ankylosis is far more prevalent in men than in women, while in unilateral ankylosis, the reverse is true. Ankylosis may occur with the hip extended or in the position of moderate or extreme flexion, associated with abduction, adduction, and rotation. The most serviceable position for ankylosis is 160 degrees flexion, 165 degrees abduction, and neutral rotation. This will permit walking by means of compensatory motion of the lumbar spine, with only a negligible limp, although much inconvenience in stooping, sitting, and climbing is experienced.

Technic.—The patient is supported by sand bags so that the affected side is uppermost. The skin incision described is a modification of that of Murphy, who in turn employed Kocher's incision for approach to the hip joint. The incision begins on the crest of the ilium about 3 inches posterior to the anterior superior spine, passing forward along the outer margin of the crest of the anterior superior spine, thence downward with slight convexity inward on the anterolateral aspect of the thigh to about 1 inch below the level of the greater trochanter, then curved sharply backward, terminating below and at the posterior aspect of the greater trochanter. The superficial fascia and fascia lata are incised. Above, the gluteus medius muscle is severed from the ilium and all structures detached from the anterior superior spine. Dissection is then made down to the hip joint through the line of cleavage between the gluteus medius and the tensor vaginae femoris muscles. The greater trochanter is exposed at the lower angle of the incision, severed

from the femur by a broad osteotome, and retracted upward with its attached muscles. The capsule is then exposed and incised parallel with the most accessible portion of the neck of the femur. With a heavy elevator, all adherent tissue is removed from the neck of the femur and the ilium, giving a complete exposure of the hip joint.

Smith-Petersen Incision.—From a point 3 or 4 inches below the anterior superior spine a vertical incision, following the external border of the sartorius muscle, is made upward to the spine of the ilium; thence carried backward following the iliac crest for two thirds of its extent. The insertions of the gluteus medius, gluteus minimus and tensor fasciae femoris muscles are stripped subperiosteally from the dorsum of the ilium with a sharp elevator, and the joint is exposed by blunt dissection through the intermuscular plane between the sartorius muscle anteriorly and the tensor fasciae femoris muscle posteriorly. The only structure divided is the tensor fasciae femoris, which is split along the course of its fibers. The incision into the capsule of the joint is made in the superior portion of the capsule just above the border of the Y-ligament of Bigelow.

Correction of Deformity.—The line of union between the head of the femur and the ilium is not always visible, as osteous fusion may be so completely organized that the neck of the femur is structurally continuous with the ilium. Fusion is severed by a curved osteotomy conforming to the head of the femur, beginning at a point about $\frac{1}{4}$ inch above the acetabulum. A large wood-carver's chisel, as suggested by Baer, is used. The hip is next dislocated by forcible abduction and external rotation, giving an excellent view of the head, neck, and acetabulum. Should adhesions on the inferior aspect of the acetabulum make dislocation difficult, they may be freed as the head of the femur is disengaged. Attention is next directed to all contracted soft structures which must be severed before reconstruction of the articular surfaces. After the tissues about the joint have been relaxed and the hip placed in the most serviceable position, the articulating surfaces are remodeled. The head of the femur is made globular and slightly smaller than normal by the excision of about $\frac{1}{4}$ inch of bone, and the acetabulum is divested of all cartilage. When manual traction is made on the leg there should be $\frac{1}{2}$ to 1 inch space between the articulating surfaces. The head of the femur and the acetabulum are then made smooth, a shoemaker's rasp being used for the head of the femur and a Murphy reamer for the acetabulum. Especial care should be taken that no loose particles of bone remain in the joint to become later the source of irritation and proliferation and provoke recurrence of ankylosis.

Interposition of Fascia.—A second incision is made through the outer aspect of the thigh and a sheet of fascia, usually from 6 to 8 inches in length and 4 inches in breadth, is removed. One end of the transplant is stitched to the soft tissues along the upper margin of the acetabulum; the fascia is then cupped to invest the raw surface of the acetabulum, and the remaining portion is made to surround the head of the femur completely. Number 2 chromic catgut is drawn through drill holes in the neck and sutured through the membrane in purse string fashion, holding the membrane firmly and closely to the head of the bone to prevent its becoming dislodged in reduction. The head is then replaced within the socket and gentle motion is made to test the ease of joint action. The pedunculated flap described by Murphy may be employed, especially in cases where fascia lata must be conserved for use in other joints. In order to secure the pedunculated fascial transplant, the lower end of the skin incision must be continued and the fascial flap secured by dissecting the flap from below upward. After the joint is reconstructed, the capsule is closed without tension when possible, or if this is impossible, an approximation of the deep muscle is quite sufficient. The trochanter is reattached by No. 2 chromic catgut passing through drill holes in the bone. Nails or other foreign material are unnecessary and their use should be avoided. The deep fascia is united by No. 1 chromic catgut and the skin by dermal suture.

After-treatment.—When the operation has been completed, strips of adhesive plaster 2 inches wide are attached to both sides of the limb from the upper third of the thigh to the ankle, with the free ends extending about 6 inches below the foot. A plaster cast is applied from the nipple line to the ankle on the affected side and to the knee on the opposite side, in order to fix the opposite hip and stabilize the pelvis. Thick padding is applied from groin to ankle, which leaves a space between the cast and the limb, permitting traction on the hip without the slightest impingement of the cast. When the patient is placed in bed, the adhesive strips are attached to an ordinary Buck extension apparatus at the foot of the bed, with from 10 to 20 pounds of weight. On the tenth day, the cast is bivalved on the affected side from the ankle to just below the crest of the ilium, so as to permit hip flexion. Passive motion is instituted by means of a sling and pulley attached to an overhead bar. This apparatus is under direct control of the patient, and the range of motion increases and tenderness subsides, the movements are gradually increased. Active motion is encouraged as soon as possible and function is gradually induced. Physiotherapy, though by no means essential to success, is a useful adjunct and should be

continuously employed for one year, when possible. Function may be restored by the intelligent cooperation of the patient, if physiotherapy is

Fig. 173.—After-treatment following arthroplasty of the hip by overhead pulley and sling.

Fig. 174.—Range of motion following arthroplasty of hip. Full extension.

Fig. 175.—Same as Fig. 174. Ninety degrees flexion.

not available. The cast is removed at the end of four to six weeks and the patient permitted to walk with crutches. Increase in weight-

bearing is governed by the density of the head and neck of the femur, as demonstrated by the roentgenogram. In some cases, apparatus such as the Thomas caliper brace or the Bradford abduction brace may be used to permit weight to be borne gradually on the foot as the tensile strength of the bone increases. In unilateral ankylosis, crutches are

Fig. 176.—Bony ankylosis of hip.

Fig. 177.—Hip after arthroplasty for ankylosis.

discarded by the end of two or three months, but must be continued for a much longer period when the affection is bilateral. Active motion, with vigorous exercises, must be strictly enforced for one year, in order to repair the atrophic muscles which have often been inactive over a period of many years.

Arthroplasty of the Elbow

The most frequent cause of ankylosis of the elbow, as in other joints, is acute pyogenic infection, however, trauma induces osseous fusion more frequently in the elbow than in any other joint. A distinction must be made between excision and arthroplasty: excision is the wide resection of bone, whereas arthroplasty is the reconstruction of all the component parts of a joint. The aim of excision is motion and the result is usually pseudarthrosis, or a loose, unstable joint. The aim of arthroplasty is the reestablishment of function by the reconstruction of all the component parts of a joint. Contraindications to arthroplasty of the elbow are rare. In ankylosis from tuberculosis, excision is preferable, though tuberculosis is not of frequent occurrence in this joint. A change in the structure of the bone—for example, dense eburna-

tion following osteomyelitis, or osteoporosis—may to some extent diminish the chances of success, but by no means contraindicate arthroplasty in the elbow as in the weight-bearing joints.

Technic.—An incision from 6 to 8 inches in length is made on the posterior aspect of the arm and forearm, just external to the midline, beginning above at the middle of the humerus and ending from 2 to 3 inches below the elbow joint. The skin, superficial and deep fascias are incised without separation. The deep fascia is dissected laterally about 1 inch, bringing into view the broad aponeurosis of the triceps muscle. With ankylosis in extension, this structure is severed transversely at the upper extremity of the incision and divided along its internal and external borders; being dissected from above downward, a long tongue of dense fascia is formed, attached to the tip of the olec-

Fig. 178.—Range of motion following arthroplasty of elbow. Active extension.

Fig. 179.—Same as Fig. 178. Active flexion.

ranon process. A further incision in the midline passes through the muscular fibers of the triceps and periosteum over the lower half of the humerus. A periosteal elevator is next employed to strip the periosteum from the lower third of the humerus, after which the head of the radius and olecranon process is exposed. Fusion between the olecranon and humerus, and radius and humerus, is severed with a curved chisel. The joint is then flexed and dislocated to the mesial aspect. The lower extremity of the humerus is made into one condyle convex from before backward. No attempt is made to reproduce the anatomical contour of the capitellum and trochlea. The superficial bone is excised from the sigmoid cavity with a curved chisel and the head of the radius is denuded to the level of the inferior portion of the sigmoid cavity. A rasp renders all surfaces smooth. A large strip of fascia lata from the lateral aspect

of the thigh is next transplanted and sutured over the lower extremity of the humerus, after which it is reflected over the sigmoid cavity; thus, a closed sac is fashioned simulating the normal structure of the joint. When synostosis exists between the ulna and radius, sufficient bone is excised to permit free rotation of the radius. A fold of the fascia is reflected between the radius and ulna and the head of the radius is invested, or a separate sheet is placed about the head of the radius and retained by a purse string suture. The articulation is reduced and the capsule closed from below upward with the elbow flexed at right angle. The tongue of the triceps aponeurosis, when severed, is sutured at a

Fig. 180.—Ankylosis of elbow.

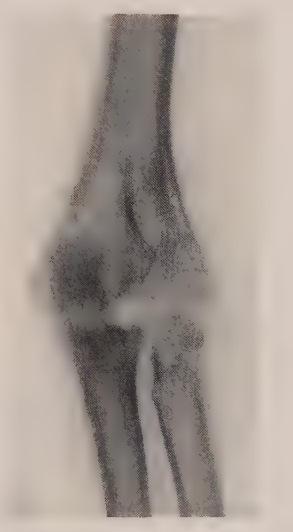


Fig. 181.—Elbow after arthroplasty for ankylosis.

lower point than its former attachment, thus permitting free play of the joint in flexion. The deep fascia and skin are closed in the routine manner.

In cases where the supply of fascia is exhausted, the aponeurotic tongue of dense fascia has been used for interposition between the articular surfaces. Also, in some of the cases, the lower fibers of the triceps may be stitched to the anterior capsule. When ankylosis exists with the elbow flexed, the triceps is not severed transversely, but is divided by a longitudinal incision along the lateral border and retracted to the inner aspect. Conservation of a portion of the articular surfaces is at times possible. A partial arthroplasty, or hemiarthroplasty of the joint, may be employed in such cases. MacAusland has described

a technic for arthroplasty of the elbow in which the joint is entered by a U-shaped incision and the olecranon process severed transversely. A new trochlear articulation, olecranon fossa and smooth sigmoid cavity are formed, and covered with a free transplant of fascia lata.

After-treatment.—Immediately following operation, the arm is immobilized in a right-angle splint or cast for ten days or two weeks. When healing is complete, the splint or cast is removed every two hours and active and passive motion are instituted with the aid of special apparatus. The exercises should continue for a few minutes on each occasion and the range of motion be increased gradually.

Arthroplasty of the Temporomaxillary Joint

Ankylosis of the temporomaxillary articulation, or the jaw, is a very serious disability, and is virtually always caused by pyogenic infection, such as osteomyelitis, which invades the condyle or even the ramus of the inferior maxilla. The structure is changed by the extensive osteomyelitis into dense, eburnated bone, and the affected portion of the mandible becomes massive and hypertrophic, often two or three times the normal size. The joint space is obliterated and the bony structure of the condyle may be continuous with that of the temporal bone. As dental hygiene is not possible, oral sepsis of a severe degree is always associated.

Distinction between the affected and the unaffected sides must be carefully made. The affected side is somewhat smaller and underdeveloped as compared with the normal. When motion is attempted, the chin moves toward the unaffected side. By palpation over the normal joint, motion may be detected, but if both jaws are ankylosed no motion is present. As periarticular ankylosis may closely resemble intra-articular ankylosis of the jaw, differentiation is necessary to avoid an unnecessary incision into a normal joint. Extra-articular ankylosis is caused by fulminative infection of the cheek and alveolar processes, as noma, which may terminate in complete osseous fusion of the alveolar process, or in strong fibrous union. The external appearance of the extra-articular and intra-articular varieties of ankylosis is identical, but on retraction of the lips, the real pathology and cause of the inability to open the mouth are apparent. There are no contraindications to arthroplasty of the jaw. The disability is so great, so distressing and embarrassing and the results so uniformly satisfactory that mobilizing operations should be performed in all cases.

Technic.—The field of operation must be carefully prepared, the hair being shaved for 2 or 3 inches over the temporal region. The

external auditory meatus is well cleaned, sponged with alcohol, and plugged with sterile cotton. Local or general anesthesia may be employed in unilateral ankylosis, but if bilateral, local anesthesia should be used and both jaws operated upon at the same time. However, if desired, after the fusion has been severed and the new joint constructed on one side, general anesthesia may be employed during the operation on the opposite side. When general anesthesia is employed, a tracheotomy set should always be sterilized and available on the operating table.

A skin incision is made about $\frac{1}{2}$ inch anterior to the external auditory meatus extending along the zygomatic process for about $1\frac{1}{2}$ inches; dissection is made down to the zygoma, thence downward to the ankylosed temporomaxillary articulation. If there is not sufficient space to

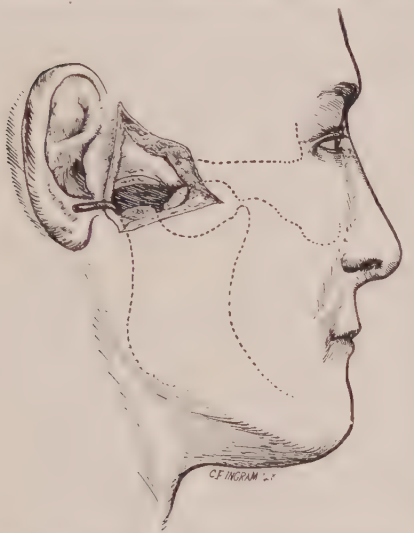


Fig. 182.—Excision of bone for arthroplasty of jaw.

Fig. 183.—Range of motion following arthroplasty of jaw.

proceed, the skin incision is carried upward for $1\frac{1}{2}$ inches at right angle to the beginning of the incision, thus forming an L. Care must be taken not to sever the ascending branch of the facial nerve, which lies just anterior to the external auditory meatus near the main branch, which passes below the temporomaxillary articulation. When the ankylosed joint has been reached and about 1 inch of the condyle is apparent, the osseous fusion is severed with a sharp chisel. Care should be taken not to pass through too far on the inner side, as there may be a troublesome hemorrhage from the internal maxillary or internal pterygoid arteries. About $\frac{1}{2}$ to $\frac{3}{4}$ inch of bone is excised from the condyle, which is rendered convex by a file. A cavity is also excavated on the temporal bone. After

the joint has been thus remodeled, a pedunculated flap of fat and fascia from the temporal muscle, as advocated by Murphy, or a free transplant of fascia lata or other membrane, may be interposed, However, it has been demonstrated that interposition of material is not necessary in the jaw. The wound is closed in the routine manner and a simple dressing applied with collodion.

After-treatment.—When pain and tenderness have partially disappeared, which, as a rule occurs in a few days, active motion is instituted. After a few weeks, full motion is often possible. Chewing of gum is a convenient and satisfactory form of exercise. The jaws may be separated daily by a mouth gag or by inserting a pack of tongue depressors between the teeth, the thickness of which is gradually increased by adding an additional depressor. Physiotherapy is a useful adjunct but is not essential as success may be obtained if cooperation of the patient can be secured. So soon as there is sufficient space between the teeth, the services of a competent dentist are required not only to repair the teeth, but also for the purpose of restoring the proper occlusion, which may have been impaired by irregular development of the jaw, or by excision of bone at the joint.

Arthroplasty of Multiple Ankyloses

Multiple or diffuse ankyloses, as a result of pyogenic infection, are not infrequently observed. In fact, every joint in the body may be involved in an extensive pyogenic infection. Obviously, the greater the number of joints involved, the less the chance of functional restoration, as the rigidity of other joints prevents the cultivation of function in any one joint after operation. This type of ankylosis opens a larger field for arthroplasty, the scope of which offers possible relief to a class of cases which has hitherto been considered hopeless. Each case presents an individual mechanical problem, depending not alone upon the number of joints involved, but also upon the position in which ankylosis has occurred. More bone must be excised than in single arthroplasties and ingenious devices must be evolved to meet the requirements of each case. The prognosis is always better if the upper extremities are normal, so that passive motion may be instituted under direct control of the patient. The elapse of time between the procedures must be as short as possible, because functional activity in one joint is promoted by the use of other joints. Multiple arthroplasties are well borne, but sufficient intervals must elapse after each operation to enable the patient to recuperate and regain some of his normal strength. An interval of three or four weeks is ample in the average case, but the de-

cision must depend largely upon the estimation of the hemoglobin content of the blood and the urinalysis.

BIBLIOGRAPHY

Baer, William S.: Arthroplasty with the Aid of Animal Membrane, Jour. Bone and Joint Surg., 16:1, 1918.

Ibid.: Arthroplasty with the Aid of Animal Membrane, Am. Jour. Orthop. Surg., 16:1, 94, 171, 1918.

Bennett, George E.: Lengthening of Quadriceps Tendon, Jour. Orthop. Surg., 1:530, 1919.

Brackett, E. G., and Osgood, R. B.: The Popliteal Incision for the Removal of "Joint Mice" in the Posterior Capsule of the Knee-Joint, Boston Med. and Surg. Jour., 165: 925, 1911.

Campbell, Willis C.: Reconstruction of Ankylosed Joints, Med. Jour. and Rec., 122:255, September, 1925.

Ibid.: Arthroplasty of the Hip, Surg. Gynec. and Obst., 43:9, 1926.

Ibid.: Arthroplasty of the Elbow, Ann. Surg., 76:615, 1922.

Koontz, Amos K.: Dead (Preserved) Fascia Grafts for Hernia Repair, Jour. Amer. Med. Assoc., 89:1230, October 8, 1927.

MacAusland, W. R.: Arthroplasty of the Elbow, Surg., Gynec. and Obst., 33:223, 1921.

Murphy, J. B.: Arthroplasty, Ann. Surg., 57: 593, 1913.

Nageotte, J.: Les Substances Conjontives Sont des Coagulums Albuminoids du Millieu Interirur, Compt. Rend. de la Soc. de Biologia, 79: 883, 1916.

Putti, V.: Arthroplasty, Jour. Orthop. Surg., 3:421, 1921.

Smith-Petersen, N. M.: A New Supra-articular Superiosteal Approach of the Hip-Joint, Amer. Jour. Orthop. Surg., 15: 592, 1927.

Sudhoff, W.: Anatomisch Histologische Untersuchung eines Falles on Blutig Mobilisiertens Elbowgengelenk, Beitr. z. klin. Chir., 123:655, 1921.

CHAPTER VIII

TRAUMATIC ARTHRITIS

Trauma undoubtedly exerts an important selective action in determining the site of a pathologic process in many joint affections. A slight blow against a joint is often followed by a violent reaction of swelling and increased fluid, which could not possibly be accounted for by such a simple injury. This reaction is often observed in middle-aged persons with a gouty diathesis and a mild injury of a joint may often instigate an infection from a distant focus, as a gonorrheal urethritis. In such instances, trauma can only be regarded as a predisposing factor, and the process should be classified according to the active causative agent. However, trauma is frequently the chief etiologic factor in many joint affections, inducing arthritis which may run an indefinite course, including the acute and subacute or chronic stages.

ACUTE TRAUMATIC ARTHRITIS

Traumatic arthritis, or sprain, is induced by wrenching, stretching, and tearing of the ligaments of a joint by direct or indirect violence. The extent of the local reaction is in direct proportion to the severity of the trauma and the resistance of the tissues. The injury is usually followed by an immediate local reaction, although a few hours may elapse before symptoms are noticeable, and occasionally, several days may pass before manifestations within the joint are apparent. This late manifestation of symptoms is probably due to the fact that cartilage is an inert substance which requires several days for vascularization and innervation.

Symptoms and Diagnosis.—The symptoms are pain, swelling with obliteration of bony prominences by increase of synovial fluid and extravasation of blood, discoloration of the skin, and impairment of function. Fluctuation may be apparent from distention of the synovial cavity with fluid, which is mixed with blood in varying proportions—a typical synovitis. Ligamentous displacements, ruptures, and tears of muscles and tendons are often associated; also there may be intra-articular and extra-articular fractures of small particles of bone. The so-called sprain fracture is the breaking loose of a small particle of bone

by ligamentous or muscular pull. The diagnosis is evident from the history and local manifestations. The prognosis is excellent in those receiving efficient treatment, although a subacute arthritis may, at times, persist indefinitely. A roentgenological examination is imperative and may demonstrate fractures and luxations, although more frequently only a distention of the joint capsule will be apparent. The treatment will be considered only in those joints most often subjected to trauma.

Traumatic Arthritis of the Ankle

The symptoms and local manifestations of acute traumatic arthritis or sprain of the ankle joint are pain, swelling, ecchymosis, and impairment of function. The only treatment worthy of description is that devised by Gibney.

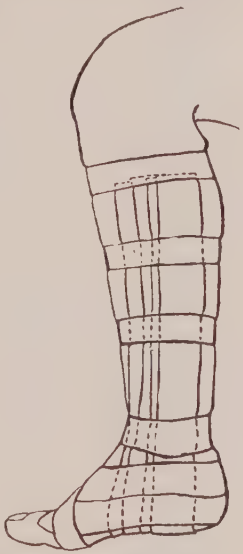


Fig. 184.—Method of applying Gibney strapping for traumatic arthritis of ankle.

Gibney Adhesive Strapping.—All hair is shaved from the affected foot, ankle, and lower two thirds of the leg. Strips of adhesive tape of from $1\frac{1}{2}$ to 2 inches in width and about 2 feet in length are prepared. The patient reclines on a table or sits in a chair with the knee flexed at right angle, and the foot held at right angle to the leg. This position is most important, but is often not strictly enforced, as the natural tendency is to extend the knee and permit the foot to fall into the equinus position by gravity, thus preventing efficient fixation. The correct position is facilitated by looping a bandage about the forefoot and having the patient make a direct pull upon the two ends of the loop, thus maintaining the foot at right angle to the leg. One end of the first strip of adhesive tape is placed against the outer aspect of the leg at the junction of the middle and upper thirds, and is passed down the outer aspect of the leg over the outer malleolus; then under the arch, making firm upward pressure against the arch by traction upon the inner extremity of the strip as the remainder of the strip is applied to the inner aspect of the leg. The strip terminates at the junction of the upper and middle thirds on the inner aspect of the leg, opposite the starting point on the outer aspect. A second strip is placed at right angle to the first, beginning on the outer aspect of the foot over the cuboid bone, and is then passed backward along the outer aspect of the dorsum of the foot and behind the heel, making forward traction. The remainder is

placed against the inner aspect of the dorsum of the foot, terminating anteriorly over the internal cuneiform bone. Successive strips, as above described, are placed about the leg and foot until the ankle is encased, except for a small area in the midline on the anterior surface. The tape is made to adhere snugly by gentle but firm rubbing, after which circular strips about $\frac{3}{4}$ inch in width are placed about the foot and leg to retain the dressing securely. This dressing should be applied as soon as possible after the injury to prevent swelling. Walking is encouraged and can usually be accomplished without pain. The same treatment may be effectively employed when insignificant fractures are a complication. Two or three dressings at weekly intervals are usually sufficient to effect a cure. In resistant cases, after the third dressing, a thin leather corset about the foot and ankle which may be worn indefinitely may supplant the adhesive plaster.

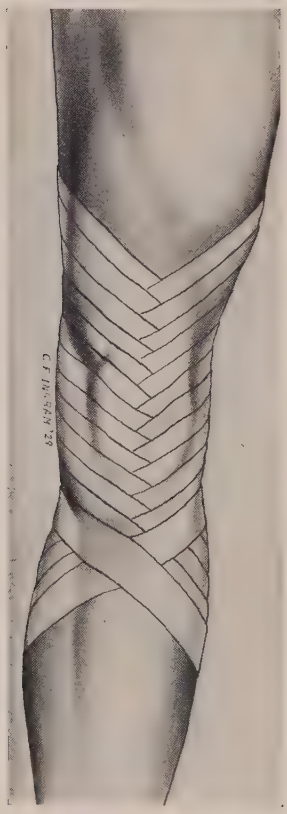


Fig. 185.—Strapping of knee with adhesive plaster. Basket weave method.

Traumatic Arthritis of the Knee

The symptoms of sprain of the knee are similar to those of other joints, except for the early evidence of increase in intra-articular fluid. The knee is a superficial joint and also the largest joint in the body; therefore, accumulation of fluid is readily apparent. In mild injuries, only strapping or bandaging may be required, but the knee does not respond so rapidly to such measures as the ankle. Following severe trauma with increased tension by excessive fluid, the joint should be aspirated, after which a firm compression bandage is applied. When there is a reaccumulation of fluid, a second or third aspiration may be necessary. Unlike the ankle, sprain of the knee may be complicated by derangement of the intra-articular structures. Special precautions are necessary in the knee joint to avoid overlooking such frequent complications as displaced semilunar cartilages and tears of the lateral ligaments. Absolute rest of the knee is essential and is accomplished by a posterior splint or plaster cast extending from the gluteal fold to the ankle. Rest in bed is advisable until the

acute symptoms have subsided. The splint is removed at the end of three weeks, when inspection is made, and if local manifestations, such as increased fluid persist, the splint or cast is reapplied for two or three weeks longer. Physiotherapy, if possible, should be employed daily and continued until the excess fluid has entirely disappeared.

Traumatic Arthritis of the Hip

In children, sprains involving the hip joint should not be lightly dismissed, as serious injury to the upper femoral epiphysis may later become apparent; also, a tuberculous process may be instigated in those with latent tuberculosis. If a slight limp without spasm of the muscles exists, the child should be kept in bed until all evidence of injury disappears. Traction by Buck's extension is indicated in those with muscle spasm. When walking is permitted, careful observation should be continued for a month or more. In adults, trauma more frequently causes injury to the muscles about the hip joint than to the joint itself, which may be treated effectively by physiotherapy. However, when symptoms indicative of joint involvement are present, the same measures as those employed in children are used. Rarely a Thomas caliper splint is required to relieve the affected joint of weight-bearing in walking.

Traumatic Arthritis of the Lumbosacral and Sacro-iliac Joints

Acute traumatic arthritis of the lumbosacral articulation and the sacro-iliac joints is of such frequent occurrence as to require special consideration.

Anatomy.—The lumbosacral joint is the largest articulation in the spine, and more motion occurs at this point than in any other joint of the spinal column. The upper surface of the sacrum inclines downward and forward at an angle of about 42.5 degrees, when the person is standing erect, and were it not for the presence of supporting structures, the lumbar vertebrae would slide forward on the sacrum. These structures are the ligaments of the lower spine and pelvis and the articular facets of the sacrum with which the lower articular processes of the fifth lumbar vertebra engage. The articular facets in the lumbar region normally face downward with a slight convergence anteriorly, which blocks forward dislocation of the vertebrae. As pointed out by Goldthwait, however, the lumbosacral facets frequently correspond in type to those of the dorsal vertebrae. The inferior articular process of the fifth lumbar vertebra may face outward to articulate with the corresponding facet on the sacrum which faces inward. The joint line is then clearly visible

in the anteroposterior roentgenogram. Such a condition materially predisposes to sprain and dislocation. The ligaments, particularly the iliolumbar which passes from the body and transverse processes of the fifth lumbar vertebra to the crests of the iliac bones, afford considerable support, but would soon become stretched if the major resistance were not offered by the articular processes. While the sacro-iliac joints are true joints, having all the structures peculiar to a joint, there is merely a capillary interval between the contiguous surfaces of the sacrum and ilium. These surfaces are covered by hyaline cartilage and the joint is surrounded by an articular capsule. The anterior sacro-iliac ligament is

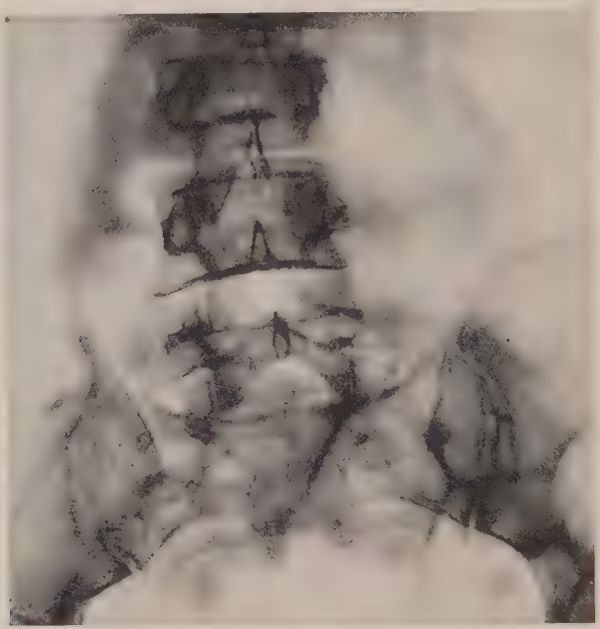


Fig. 186.—Congenital malformation of spine. Articulation of lumbosacral facets visible in anteroposterior plane.

thin, but consists of strong short fibers. The posterior ligaments are strong, and the joint is further reinforced posteriorly by the iliolumbar, sacrotuberous and the sacrospinous ligaments. Normally, slight motion is a definite function of the sacro-iliac joints.

Etiology.—Continued strain, after long stooping or standing in awkward positions, lifting or straining, especially if the load is suddenly increased, may rupture some of the sacro-iliac ligaments. This allows a greater range of motion than is normal and a partial luxation of the joint. The upper portion of the sacrum is usually displaced backward on the ilia. Similar rupture of the ligaments with slight displacement

of the lumbosacral joint may result from the same forces which produce lesions of the sacro-iliac joints. As all joints of the pelvic girdle function or move together, a slight displacement of one may cause loss of perfect coaptation of all the other joints and the resulting disability may be very great. Following any traumatic lesion of a joint a point of lowered resistance may be established and hematogenous infection may occur from a distant focus. This complication causes an undue prolongation of the symptoms and obscures the diagnosis.

Symptoms and Diagnosis.—In lumbosacral and sacro-iliac affections, pain may be local or referred. Referred pain is caused by the associated irritation of the large nerve trunks of the sacral plexus which cross anteriorly to the articulation. The symptoms are relieved by rest and aggravated by activity. In the subacute stage characteristic attitudes may be assumed on standing or walking. In affections of the sacro-iliac joint the patient may assume unconsciously a position of scoliosis known as sciatic scoliosis. The lumbar lordosis is flattened, the trunk is usually inclined away from the affected side, the gait guarded, and all motions of the spine are limited. Forward bending particularly is restricted, due to the tension on the pelvis by the hamstring muscles. There is pain in the affected region on jarring the spine. Abnormal mobility is sometimes demonstrated by hyperextension or flexion of the thighs. The examination must be systematic and careful in order to differentiate between lumbosacral lesions and those of the sacro-iliac joints. Examination of the spine should be made with the patient in three positions standing, sitting, and lying. When the patient is standing, muscular rigidity is more pronounced and the characteristic attitude is apparent; motion is also restricted to a greater degree when the patient is in this position. A sign noted in the examination of many patients is brought out by asking the patient to bend forward. Motion up to a certain point may be free and painless, but beyond this flexion causes pain, and the spine deviates from the midline, usually toward the affected side. When the patient is in the sitting position tension of the hamstring muscles on the pelvis is relaxed and forward bending is somewhat freer than in the standing position. In the recumbent position, passive movements of the spine may be carried out to practically the normal range. Localized points of tenderness may be demonstrated by pressure over the sacro-iliac joints, the insertion of the ligaments, or over the sciatic nerve at its exit through the sciatic notch of the pelvis. With the patient on his back, the affected leg is raised with the knee extended. If pain is present on this manipulation, the Kernig sign is positive. As pointed out by Goldthwait, this sign is

often present in spinal affections. Compression of the iliac crests is also a valuable diagnostic sign. The patient lies on the suspected side and the examiner presses downward over the opposite iliac crest; if the sacro-iliac joint is involved, pain in the affected region is felt on firm pressure. A variation of this sign, though not so valuable, is direct backward pressure over the pubic bones. The Gaenslen sign, as described in the chapter on Examination, is also of value in differentiating lumbosacral and sacro-iliac affections and in determining which sacro-iliac joint is involved. In affections of the lumbosacral articulation, differentiation from sacro-iliac lesions is difficult, as the symptoms of the two conditions may be almost identical. The pain and tenderness, however, may be localized in the midline over the lumbosacral joint, the rigidity of the spine is more exaggerated, and the characteristic symptoms of sacro-iliac affections, as tenderness over the sacro-iliac joint and pain on compression of the iliac crests, are absent.

Treatment.—The aim of all treatment is immobilization to relieve pain on movement until organization has occurred and the ruptured ligaments have been repaired. In mild cases, adhesive strapping offers a convenient method of fixation and gives prompt relief. The adhesive plaster strips, 2 or 3 inches in width, are applied snugly around the pelvis, beginning just anterior to the anterior superior spine and passing across to the opposite side. Two or three overlapping strips are applied and reinforced by two or more diagonal strips. A pad of felt may be placed over the sacrum and held in place by the adhesive tape, especially in those who have exaggerated lumbar lordosis. Recumbency on a Bradford frame for a period of six to eight weeks may be indicated, with gradually increased traction on both legs using 6 to 10 pounds of weight. Pads of felt or other resilient material are so placed that the lower lumbar spine is elevated and supported and the normal lumbar lordosis restored. Later a sacro-iliac belt or low spinal brace will give support and must be worn until all symptoms have disappeared. Baking and massage are valuable adjuncts to the mechanical treatment. When obvious foci of infection are present, they should be eradicated by appropriate surgical procedures.

When symptoms persist regardless of conservative measures, operative procedures for fusion similar to those performed in tuberculous spondylitis are necessary. Also, when symptoms are severe at the onset, or have been present for a long time, causing continuous disability, fusion is indicated. For the lumbosacral region the Albee or Hibbs type of fusion may be employed or an osteoperiosteal graft may be used to fuse the lower lumbar vertebrae to the sacrum. A transplant from the

curved portion of the crest of the ilium may be used in conjunction with extra-articulation fusion of the sacro-iliac joint. This transplant conforms to the normal lumbar lordosis of this region.

Traumatic Arthritis of the Spine

Acute traumatic spondylitis, following contusions or wrenching of the spinal column, is of frequent occurrence, especially in those whose occupations are laborious. The spinal ligaments may be ruptured or sprained with an accompanying extravasation of blood into the tissues, swelling, and induration. Congenital malformations of the spine are undoubtedly a predisposing factor in traumatic spondylitis. Congenital variations are most commonly seen at the junction of the anatomical regions of the spine; the cervicodorsal, the dorsolumbar, and the lumbosacral. Those most frequently seen in association with traumatic spondylitis are numerical variations of vertebrae, cervical ribs, spina bifida occulta, abnormality of conformity of the articular processes, increase of the normal obliquity of the lumbosacral articulation, lack of fusion of the laminae and pedicles of the vertebrae and enlarged transverse processes of the fifth lumbar vertebrae with or without sacralization.

Traumatic spondylitis, as arthritis of other joints, is manifested by pain, tenderness, and reflex muscular rigidity which limits function. The symptoms may be observed immediately after injury, or may not become apparent for a few hours or even a few days. Occasionally, there may be an associated spinal cord injury. The diagnosis is usually obvious from the history and the symptoms, but a roentgenogram should always be made to exclude fracture and destructive lesions. Trauma, especially of the cervical region, may induce symptoms closely resembling tuberculosis, and in children when no history is obtainable, the diagnosis may be difficult as the symptoms may persist indefinitely. In mild cases physiotherapy combined with some light supportive appliance, as adhesive strapping, is usually sufficient to insure prompt and complete recovery. In severe cases, recumbency on a Bradford frame with traction to the head when the injury is to the cervical or upper dorsal spine, and traction to both legs when the injury is to the lower dorsal or lumbar segments of the spine, is necessary. The wearing of spinal braces, as the Taylor or Steindler brace, is often advisable for several months following the injury, as the prognosis in all spinal injuries is uncertain and every case should be treated with great care. The medicolegal aspect of such injuries, as well as those of other regions, must always be borne in mind, as neurosis may develop, causing the painful symptoms to persist until the well known syndrome of railway-spine is developed.

Kümmell's Disease.—The clinical entity developing subsequently to spinal injury, which has been described by Kümmell, consists of a rarefying osteitis of one or more vertebrae. The exact etiology is in doubt; some authorities claim that the pathologic changes are due to unrecognized fractures, with softening of the resulting callus from too early resumption of functional activity. The symptoms are not manifested until some weeks or months after the injury when there is pain at the site of the lesion, and a gradually developing kyphos, simulating tuberculosis of the spine. The disease is seen most often in young adults and usually involves the dorsal vertebrae. The treatment consists of immobilization of the spine until the symptoms have disappeared. This may be accomplished by plaster casts or braces, but if these measures do not prove successful fusion of the affected region is indicated.

Fig. 187.—Kümmell's disease with kyphos.

Fig. 188.—Kümmell's disease.

Traumatic Arthritis of the Shoulder

Trauma in the region of the shoulder more often injures the extra-articular than the intra-articular structures. The tendon of the long head of the biceps may be overstretched or even transversely ruptured. This usually occurs in the bicipital groove of the humerus. The symp-

toms are pain, tenderness on pressure, and rarely apparent swelling, which may persist for weeks or months. Passive motion is comparatively painless, but any attempt at active motion as flexion of the shoulder in handling a dish at the table often induces such severe pain that the extremity is paralyzed reflexly and the arm falls to the side. When the supraspinatus tendon is ruptured, there is limitation in abduction and tenderness over the insertion of the tendon into the greater tuberosity of the humerus. The process may be confined to the joint entirely with symptoms of a definite intra-articular arthritis with intra-articular adhesions. Discrimination must always be made from bursitis associated with trauma which is described in the section on bursitis. In those with mild symptoms, hot applications, baking and massages may be the only treatment required. When effusion and swelling persist, physiotherapy should be continuously and conscientiously employed, as all injuries to the shoulder have a tendency to become subacute or chronic. When there is definite severance of a tendon, incision and suture of the fragments are indicated.

Traumatic Arthritis of the Elbow

Intra-articular and extra-articular injuries to the elbow without fracture are not uncommon and are peculiarly resistant to treatment. There may be an injury to the upper radio-ulnar articulation by sudden overpronation or oversupination, which is followed by pain over the articulation with limitation in rotation. When the joint proper is involved, motion is limited chiefly in extension and may persist indefinitely. There is often an associated injury to the brachialis anticus muscle with contracture, or, especially in children, a strip of periosteum may be torn from the anterior aspect of the humerus, followed by bone production and blocking of joint motion. Local myositis ossificans may also develop in the brachialis anticus tendon. The treatment consists of rest in a splint for three or four days until the acute symptoms have subsided when physiotherapy together with active and passive motion is indicated. Aspiration is required when distention is present. Care must be taken not to induce further reaction by any form of treatment. When myositis ossificans is a complication, especial care must be used to avoid irritation as bone production may thus be increased. Surgical removal is indicated when there is complete organization of the process with encapsulation.

Traumatic Arthritis of the Wrist

Traumatic arthritis or sprain of the wrist is very common and may be associated with fractures and dislocations of the carpal bones, es-

pecially fracture of the scaphoid and dislocation of the semilunar bone; consequently, in all injuries to the wrist joint, the differential diagnosis must always be made with such conditions in mind. The symptoms are the same as in any other joint and may be associated with tenosynovitis. The treatment is simple strapping which may be sufficient, but if symptoms persist a leather wrist corset should be worn for several weeks or until the symptoms of pain and swelling have subsided.

Kienboch's disease is a slowly progressive osteitis of the semilunar bone, sometimes seen following injuries to the wrist. The condition is caused by the interference with the blood supply from partial disloca-

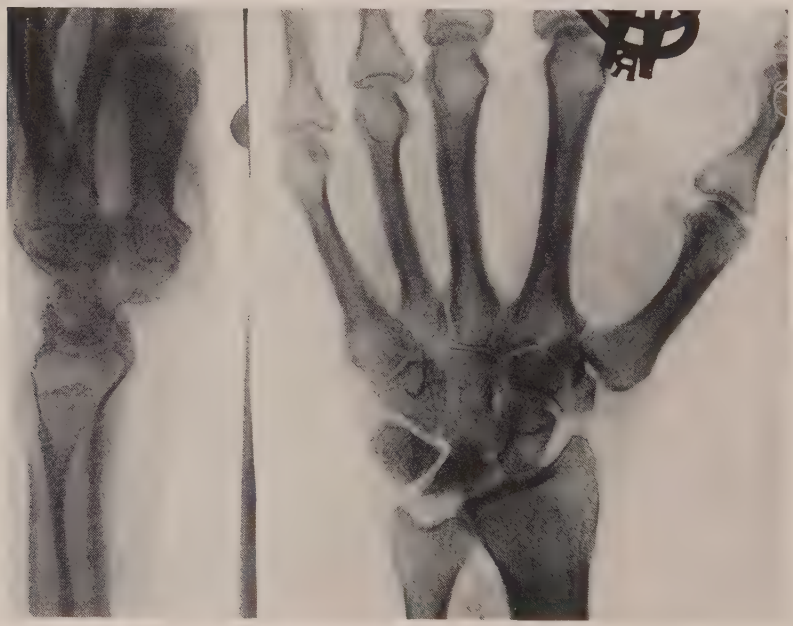


Fig. 189.—Kienboch's disease.

tion with spontaneous replacement of the bone. There is a rarefying osteitis similar to that of Kümmell's disease and the symptoms are manifested by pain on use. The treatment consists of prolonged immobilization of the wrist and rarely excision of the bone.

SUBACUTE TRAUMATIC ARTHRITIS

Etiology.—Arthritis of a subacute or chronic nature may follow an acute traumatic arthritis and persist for an indefinite period. Repeated injuries from excessive use of a joint, required in certain occupations, may cause pathologic reactions or induce derangements within the joint. Such derangements may result from recurrent displacement of

the semilunar cartilages of the knee, habitual dislocation of the shoulder, or loose bodies in joints. Static postural defects may cause an uneven distribution of weight on the articular surfaces, and this, in time, may induce irritation within the joint. However, the possibility of a coexisting infection from a distant focus must always be considered in any low-grade process, regardless of the history of previous or recurrent injury. The process in subacute traumatic arthritis is virtually always monarticular. As males are more exposed to trauma than females, subacute arthritis is more prevalent in boys and men.

Pathology.—The pathology is that caused by any continuous irritant, as joints react in the same manner to different etiologic factors and may be the same as that observed as a result of an attenuated infection. There may be an increase of synovial fluid with thickening of the synovial membrane and capsule. Also, there is observed proliferation of the synovial villi, and at times the formation of enlarged fatty masses within the joint, the so-called *lipoma arborescens*. Further reaction is thus caused by the persistent irritation of these hypertrophic articular structures which may induce degenerative changes in the cartilage as fibrillation. A local ostearthritis may be caused by insidious trauma with gradual disintegration of the articular cartilages and the formation of osteophytes.

Symptoms and Diagnosis.—The symptoms of a subacute traumatic arthritis are similar to those of a low-grade infectious arthritis. Pain may at times be present with lessened endurance of the joint. Swelling with increased fluid is often present, or on palpation there may be evidence of proliferative changes within the joint, as lobulated masses and thickened joint capsule. Local temperature may be slightly elevated. Function may be restricted in the extreme ranges of movement. Such manifestations may be spontaneously arrested or persist for an indefinite period. The diagnosis is made by the symptoms and the history. Differentiation can only be made from other joint affections by exclusion and even a biopsy may be indicated. The prognosis as to perfect recovery depends on the extent of organic changes within the joint. The damage may be irreparable but most cases can be materially benefited by efficient measures.

Treatment.—All infections in the body should be eliminated, as there is always a possibility of a coexistent infectious agent acting as a focus. Besides, the eradication of infection raises the stamina of the individual, securing a greater resistance to any abnormal process. Conservative measures, as traction, fixation, and physiotherapy are often of benefit, but when there is no improvement from such treatment,

and a proliferative synovitis persists, operative measures are indicated. These may consist in the removal of redundant tissues as lipoma arborescens that are apparently causing persistent irritation. Synovectomy, or section of the synovial membrane, from which most favorable results may be secured, is often indicated in resistent cases.

MECHANICAL DERANGEMENT OF JOINTS

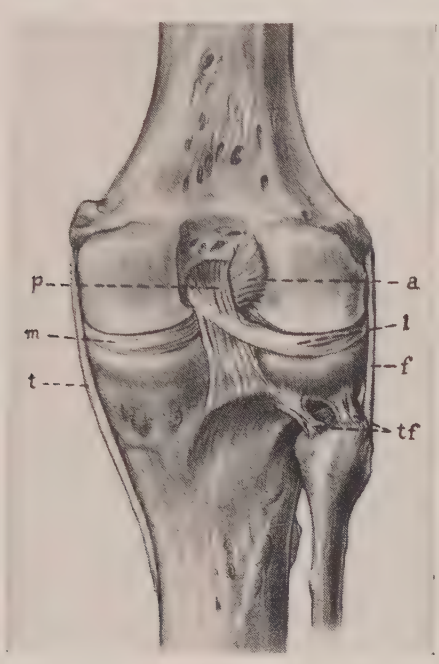
There are certain mechanical derangements occurring in the interior of joints that may be caused by various pathologic factors, but in a large percentage trauma is probably the most important causative agent. These derangements cause such typical symptoms of catching or locking of the joints and are of such frequent occurrence, especially in the knee, that special detailed consideration of that joint is warranted. Agents and factors which may induce mechanical derangements of the knee joint may be enumerated as follows: (1) Lesions of the semilunar cartilages; (2) rupture of the internal and external lateral ligaments; (3) rupture of the crucial ligaments; (4) hypertrophic villi; (5) hypertrophy of the infrapatellar fat pad; and (6) loose bodies.

Lesions of the Semilunar Cartilages

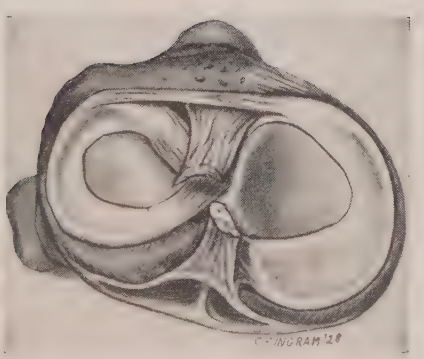
Lesions of the semilunar cartilages are by far the most frequent cause of mechanical derangements of the knee joint, and the internal semilunar cartilage is injured far more frequently than the external; according to various statistics, the ratio is about 15 to 1. The reason for this difference in incidence is largely anatomical. The inner cartilage is longer than the outer, semilunar in shape, and terminates anteriorly by bifurcating; the anterior portion of the bifurcation passes across and is attached to the external semilunar cartilage being known as the transverse ligament. The posterior extremity or horn of the cartilage is attached to the nonarticular surface of the tibia anterior to the attachment of the posterior crucial ligament. The cartilage is held in position by coronary ligaments which pass from the cartilage to the tibia; these fibers are much shorter than those of the external cartilage and do not permit much free play. The internal cartilage does not conform snugly to the surface of the tibia in any position of the joint. The mechanism which causes injury of the internal cartilage is more common than that causing damage to the external cartilage, and this also accounts for the relatively greater frequency of lesions of the internal semilunar cartilage.

Internal Cartilage.—*Etiology.*—The mechanism of injury to the internal semilunar cartilage is brought about in the majority of cases by

a sudden inward twist or torsion of the femur upon the fixed tibia, making tension on the anterior extremity of the cartilage, which may



A

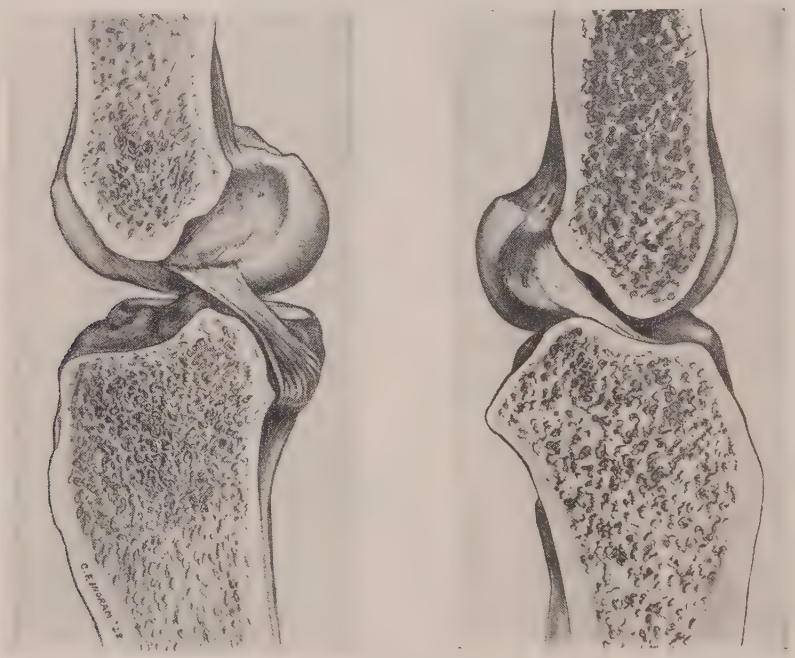


B

Fig. 190.—A, Detail of anatomy of knee joint: *p*, Posterior crucial ligament; *m*, internal semilunar cartilage; *t*, internal lateral ligament; *a*, anterior crucial ligament; *l*, external semilunar cartilage; *f*, external lateral ligament; *tf*, tibiofibular ligament. B, Anatomy of interior of knee joint showing superior surface of tibia, semilunar cartilages and crucial ligaments. Note the transverse ligaments anteriorly connecting the internal and external semilunar cartilages.

be torn loose or split. Abduction of the tibia is often associated with torsion and when present the central portion of the cartilage may be

sucked outward and nipped between the inner condyle of the femur and tuberosity of the tibia. Also abduction widens the inner portion of the articulation, permitting impingement of the internal cartilage. The posterior extremity of the internal cartilage may be caught between the articular surfaces by outward rotation of the femur when the tibia is fixed in extreme flexion, as in the squatting position. Injury of the cartilage may occur at any age, but as trauma received in athletic games is usually the causative factor, men are more frequently affected than women, and the condition is most often seen in young adults.



A B

Fig. 191.—A, Sagittal section of knee showing attachments of posterior crucial ligament. B, Sagittal section of knee showing attachment of anterior crucial ligament.

Pathology.—The cartilage may be merely contused, or may be dislocated or fractured. The dislocation may consist of displacement of the anterior horn, the posterior horn, the central portion, the entire cartilage or of a general laxity. Fractures may be longitudinal, transverse, oblique, or irregular. Fractures and dislocations may be combined.

Dislocations.—Dislocations are less common than previously considered, as many apparent displacements have been found to be longitudinal

fractures or tears. The anterior horn is more frequently dislocated than any other portion of the cartilage, as the anterior portion of the cartilage is loosely attached to the internal lateral ligament. After displacement the anterior extremity is easily caught between the articular surfaces, and may be rolled backward into the joint causing further displacement or longitudinal tears. The posterior horn may be detached and caught between the posterior portion of the articular surfaces in flexion, preventing or blocking full flexion. The central portion may be pulled within the joint when the peripheral attachment is ruptured. The entire cartilage may rarely be detached and avulsed within the joint. General laxity of the ligaments may permit excursions of the cartilage into the joint, but as this condition may be simulated by other mechanical factors, care must be taken in making such a diagnosis.

Fractures.—A longitudinal fracture of the anterior third with detachment of the anterior horn is most common, as the bifurcation of the anterior extremity of the cartilage renders this portion peculiarly susceptible to injury. When the anterior horn is detached and retracted within the joint, the transverse ligament fixes the periphery of the cartilage, while traction upon the displaced horn tears the cartilage longitudinally. The central portion of the cartilage may be caught between the articular surfaces, causing a longitudinal split and displacement of the inner half of the cartilage within the joint, the so called "bucket-handle" type. A longitudinal tear of the posterior horn may be caused by the same mechanism as dislocation. In time the anterior and posterior horns may develop nodular enlargements from constant irritation.

Transverse fractures are most common at the junction of the anterior third of the cartilage with the posterior two thirds, for the posterior two thirds is attached firmly to the capsule while the anterior third is loosely attached. A bending at this point with fracture is therefore easily induced when the anterior extremity of the cartilage is caught between the articular surfaces. A transverse T or oblique fracture may also occur at the junction of the anterior and posterior two thirds, by bending without detachment of the cartilage; this is often not apparent without careful inspection even when the joint is opened. However, by making light traction on the border of the cartilage the defect can be easily detected.

Combined Dislocations and Fractures.—Fractures of all varieties often occur subsequent to dislocations by repeated impingement between the articular surfaces. Also, fractures may be combined with dislocations at the time of the initial injury. The loose portion of the car-

tilage may be displaced within the intercondylar notch, and remain there indefinitely without causing symptoms, but more frequently is repeatedly caught between the articular surfaces. The cartilage may be ground or broken into small particles which become free or loose bodies within the joint cavity. Lesions of both semilunar cartilages are rarely observed after very severe injuries; after displacement or removal of one cartilage there may be displacement or fracture of the other cartilage by subsequent trauma.

Symptoms.—There is usually a history of definite injury to the joint with or without locking. The local manifestations vary according to the extent of damage to the cartilage, and the amount of cartilage interposed between the articular surfaces. The pain may be sudden, intense, and agonizing; the joint is locked and can not be extended beyond 165 to 150 degrees flexion. The knee joint becomes filled with fluid and the patella floats. Immediate reduction may be accomplished by jerking, flexing, and twisting the limb by the patient or another person. Subsequent displacements often occur with less severity, or, in some instances, with increasing severity, which indicates further damage to the cartilage from repeated trauma. After recurrent displacement the victim often learns how to secure reduction and also prevent impingement by involuntarily avoiding those movements of torsion by which displacement is induced. Recurrent displacements often cause other types of internal derangements, as rupture or stretching of either or both lateral ligaments, enlargement and impingement of the infrapatellar fat pad and loose bodies. Recurrent attacks may also induce a low-grade ininflammatory process throughout the entire joint with extensive proliferative changes of the synovia that may persist indefinitely. Not infrequently there may be no symptoms of locking or internal derangement, but only recurrent attacks of pain and increased fluid within the joint, which usually follow excessive exercise. On examination, unless immediately after displacement, no objective symptoms may be apparent and function of the joint may be normal, but in a majority of cases, pain is elicited by pressure over the inner attachment of the cartilage to the mesial tuberosity of the tibia, and the tibial attachment of the internal lateral ligament. Pain is also often experienced over the anterior horn when pressure with one finger is made upon the upper surface of the tibia internal to the patellar tendon. A tender point is occasionally elicited at the femoral attachment of the internal lateral ligament just below the adductor tubercle. Active and passive motion in the knee is limited in extension when the cartilage is unreduced. In rare instances, when impingement of the posterior extremity of the car-

tilage occurs, extreme flexion may be blocked by the displacement of the cartilage into the posterior compartment.

Diagnosis.—The diagnosis is made largely from the classical history unless observed after an acute injury with existing locking. Differentiation must be made from various types of arthritis and internal derangements from other causes. In low-grade arthritis there may be symptoms suggestive of derangement, but the history, roentgenogram, and other well-known tests will aid in discrimination. Rupture of the internal lateral ligament may obscure the diagnosis as the symptoms are similar to those of a displaced cartilage. However, if only rupture of the ligament is present, the locking and joint reactions are not so severe as in internal derangement. Also, when the ligament alone is ruptured there is a constant feeling of instability and insecurity in the knee joint; whereas, in displacement of the internal cartilage, the joint may feel normal between attacks. When the internal lateral ligament is stretched or ruptured, abduction may be increased when the knee is fully extended. When the infrapatellar pad of fat is impinged upon, the symptoms are less severe, and the pain and tenderness are on either side of the patellar tendon just below the patella. In loose bodies of the osseous and cartilaginous type, the symptoms are less severe and the roentgenogram will demonstrate the bodies. In rupture of the crucial ligaments there is the characteristic anteroposterior gliding of the tibia upon the femur. When the external cartilage is injured the symptoms are confined to the external side of the joint. The roentgenogram very rarely demonstrates anomalies of the semilunar cartilages. Virtually always the articulation appears normal, unless there is actual impingement between the articular surfaces, when rotation of the tibia on the femur is apparent. Roentgenograms after injection of the joint with oxygen may demonstrate the cartilage, but are of no practical value, as symptoms of derangement are sufficient to warrant exploration.

Prognosis.—The prognosis of injuries and displacements of the semilunar cartilages depends upon three factors: (1) Complications by associated internal derangements other than that of the cartilages; (2) the extent of organic changes within the joint that have been induced by constant irritation of a displaced cartilage; (3) the efficiency of the treatment. In untreated cases, a destructive arthritis with extensive proliferative changes may develop with serious consequences to the joint. Rarely, such changes may be followed by a tuberculous arthritis. In time the cartilages may be ground up and may disappear, or small fragments may form loose bodies that may further irritate the joint. If efficient treatment is instituted after the initial reduction, recovery

will follow in a large percentage. In those operated upon before organic changes are apparent, a perfect result may be expected in almost 100 per cent. If efficient operative technic is not rigidly enforced, further damage may ensue to other structures of the joint, which undoubtedly often accounts for postoperative complications.

Treatment.—If the joint is locked when the patient is first observed, reduction may be accomplished without anesthesia if cooperation of the patient can be secured. The knee is fully flexed, then the tibia is grasped at the ankle and lateral rocking on the femur is carried out in an attempt to free the cartilage from its impingement. Abduction is secured between the femur and tibia, and the space between the inner condyle of the femur and the articular surface of the tibia increased, thus releasing the cartilage. The patient is then requested to kick and the surgeon rotates the leg inward. The cartilage, by this maneuver, may be felt to snap into position. The surgeon should not at any time force extension. The patient will know immediately if the dislocation has been reduced. Ability to extend the knee voluntarily and completely is the test of reduction. As cooperation by the patient is often difficult to secure, anesthesia may be required. If the cartilage can not be reduced by manipulation, the patient should be placed in bed, with Buck's extension applied for twenty-four or forty-eight hours, when reduction may result spontaneously or second attempt by manual reduction may be successful.

The after-treatment consists of fixation of the joint for four to six weeks by a plaster cast or splint. Massage of the muscles can be instituted early with special effort toward maintaining the tone of the quadriceps, but no motion of the joint should be allowed. Weight-bearing is permitted as soon as acute symptoms subside and at the end of four weeks a brace is applied to the knee which permits flexion but as little rotation as possible. The inner aspect of the heel of the shoe is raised to remove strain from the internal lateral ligament. The brace should be employed for three months and the elevation on the shoe for six months to one year. The patient should also be instructed to toe-in when walking. If this routine treatment is efficiently and carefully followed out, a cure will be effected in a large percentage. In those giving a history of repeated dislocations, which is corroborated by physical signs, conservative measures, as a brace and elevation of the inner aspect of the shoe, may be employed, but the results of such treatment are uncertain. Even if the symptoms are relieved by conservative measures, irritation within the joint may be continued with serious complications at a later date. Consequently, if there have been more than two

recurrent attacks, when the patient is first seen, operative treatment is the one of choice.

As in all surgical procedures upon bones and joints, careful preparation of the patient and operative area is required. The operation is performed in a field made bloodless by the application of a tourniquet. The knee is placed in the flexed position and many operators prefer hanging the leg over the end of the operating table with the joint in 90 degrees flexion. There are several operative methods which may be employed, but only those of Jones and of Fischer will be considered.

Jones Technic.—The skin incision begins about 1 inch from the mesial aspect of the middle of the patella, passes straight downward parallel with the lower half of the patella and the patellar tendon for 2 or 3 inches, or to just below the articular surface of the tibia, when it is curved backward for 1 or 2 inches. Care must be taken not to injure the internal lateral ligament. After the incision is made through the skin and superficial fascia, the incision through the deep fascia, capsule, and synovia is made slightly external to that through the skin, so that the skin and joint incisions do not coincide. Blunt retractors are applied and when the interior of the joint is reached, satisfactory inspection can be made of the anterior portion of the internal cartilage. The whole procedure is carried out under the most careful gentle instrumental technic. Great care must be taken not to injure the incrusting cartilage, internal lateral ligament, and the anterior crucial ligament. If any abnormality is observed, the cartilage is held by a strong Martin clamp or heavy forceps when gentle traction is made, and the attachment of the cartilage at the periphery is divided by blunt scissors or a Freiberg knife. As much of the internal cartilage as possible is excised; usually the anterior two thirds is quite sufficient, though frequently the entire cartilage can be drawn into the anterior compartment and removed. In those cases in which the posterior extremity of the cartilage is displaced, a posterior mesial incision into the posterior compartment is made, and the posterior attachment of the cartilage is severed; the entire cartilage can then be removed by the anterior route.

Before closing the incision, careful inspection must be made of the joint to determine the integrity of other structures, as the same injury which involves the semilunar cartilage may also rupture the anterior crucial or internal lateral ligaments. Loose bodies within the joint may at times be a complication. A careful inspection of the articular surfaces should be made to discover any irregularity and the status of the soft structures of the joint should also be observed; but the removal of other structures, as large synovial villi, is usually unnecessary, unless

they are obviously a complication. If, for any reason, abnormalities are suspected in other portions of the joint and a satisfactory inspection can not be made through this incision, a fresh sterile glove is placed on the right hand and the forefinger introduced to explore the joint. The capsule is closed with plain catgut, the deep fascia with chromic catgut and the skin with dermal suture. After the wound is closed compression is made by pads and bandage over the entire knee joint. A posterior splint applied to hold the knee in full extension should be worn for twenty-four to forty-eight hours, as hemorrhage into the joint, or other damage may be caused by violent movements of the patient. The after-treatment consists of rest in bed for about ten days, after which the stitches are removed and the patient uses crutches for one week when recovery is usually uneventful and no further treatment is required.

Fisher Technic.—The incision begins at a point on the internal condyle parallel with the upper border of the patella just anterior to the femoral insertion of the internal lateral ligament, after which it is curved downward and forward with convexity below, terminating just internal to the patellar tendon about 1 inch below the patella. Fisher claims that the entire cartilage may be removed by this incision. The technic otherwise is the same as that of Jones.

External Cartilage.—*Etiology.*—The external semilunar cartilage is injured less frequently than the internal. The external semilunar cartilage is more circular and thicker than the internal, and is bound to the tibia by coronary ligaments as is the internal, but these fibers are much longer and permit more free play than is allowed to the internal semilunar cartilage. The external cartilage conforms to the articular surface when the knee is extended. The mechanism of the injury is the reverse of that causing injury to the internal semilunar cartilage. The foot is usually fixed upon the ground, the femur is rotated outward upon the tibia, and at the same time the knee may be adducted. This usually tears the posterior attachment of the external cartilage which is then avulsed within the anterior compartment; also the same mechanism may rupture or stretch the external lateral ligament. The external cartilage may also be injured or avulsed by hyperextension. The same lesions are found in the external cartilage as in the internal, but more commonly the entire cartilage is displaced as it is much thicker and heavier than the internal cartilage.

Symptoms.—The symptoms are also the same with the exception that they are apparent on the outer aspect of the knee. Locking of the knee at an angle of 90 degrees sometimes occurs. Tenderness over the external cartilage, and the attachment of the external lateral ligament

and locking are definitely on the outer side. The symptoms are said to be milder than those in derangement of the internal cartilage, though this has not been the observation of the author. Rarely, symptoms may be referred to the opposite side of the joint, due to rupture or stretching of the lateral ligament.

Treatment.—If the patient is observed directly after displacement, the treatment is immediate reduction, which is accomplished by a manipulation which is the reverse of that for the replacement of the

Fig. 192.—Cyst of external semilunar cartilage.

internal cartilage. The knee is acutely flexed and moved laterally from side to side in an effort to obtain as much adduction as possible so as to separate the external half of the joint and permit the loose cartilage to slip into its normal position. The leg is then quickly extended and the tibia rotated outward. The evidence of reduction is complete voluntary extension the same as that for the internal cartilage.

Operative Technic.—The indications for and technic of operative treatment are also similar to those employed for the internal cartilage.

A straight incision is made about 1 inch from the outer aspect of the patella parallel with the patellar tendon. This incision begins on a level with the middle of the patella and extends down to a point just below the external tuberosity of the tibia, and is continued through the soft structures to the joint in the same manner as in the approach to the internal cartilage. If more room is required, the lower end of the incision may be carried backward and outward for 1 or 2 inches, care being taken not to injure the external lateral ligament. However, the straight incision is usually sufficient as the external cartilage is often avulsed and can be easily removed. The after-treatment is the same as that described for the internal cartilage, except that the shoe is not modified.

Cysts of the semilunar cartilages may infrequently form and produce symptoms of mechanical derangement of the knee. Thirty-six cases have been reported in the literature, 10 of which have been observed by the author. Trauma is assumed to be the prime etiologic factor in spite of the fact that a history of injury is not obtainable in every case.

Fig. 193.—Cysts of external semilunar cartilage.

Pathology and Symptoms.—The external semilunar cartilage is usually affected, although similar cystic changes have been more rarely observed in the internal cartilage. The cyst is located in the middle portion of the cartilage near the peripheral border and arises in the cartilage of which it forms a part by expansion laterally pressing against the capsule of the joint and the lateral ligament. The cyst is multilocular, the larger loculi lying toward the periphery and the smaller ones centrally being separated from each other by fibrous septa. The content of the cyst is a clear mucoid or slightly blood tinged material. The lining membrane consists of a few scattered cells and deposits of fibrous-like material. There is no evidence of inflammation in the surrounding structure. The symptoms are similar to those of other derangements of the knee joint, but without locking or snapping. Pain, limp, and interference with joint motion, associated with a visible and palpable tumor in the region of the cartilage, are characteristic manifestations. The pain may or may not be constant and is aggravated

by functional use. The pain is also aggravated by rotation of the leg and is worse on full extension and flexion of the knee, the most comfortable position being at about 110 degrees flexion. The tumor is firm and resistant to pressure; the size varies, but the location is constant and unchangeable. It is always immediately overlying the cartilage on a level with the joint line and is firmly fixed to the tibia and moves with the tibia in all movements of the knee joint.

Diagnosis and Treatment.—The condition must be differentiated from other internal derangements, but this is not difficult because of the absence of history or locking. Cysts of the cartilages must be differentiated from bursitis, and this may be more difficult, but the diagnosis can be made from the location of the cyst. The roentgenogram is negative, though in some instances the cyst may be visible as a shadow in the soft tissue. Injections of oxygen into the joint may be of value in demonstrating the tumor. The treatment should consist of excision of the entire cartilage as recurrence has been reported following simple excision of the cyst.

Rupture of the Lateral Ligaments

As the integrity of the knee joint depends almost entirely upon ligamentous support, rupture of the lateral ligaments of the knee causes greater disability than similar injuries to other joints. Rupture of the internal lateral ligament is caused by overabduction of the leg, and rupture of the external ligament by overadduction.

Symptoms.—Excess lateral motion is present. After acute injury there is pain, increased intra-articular fluid, swelling, ecchymosis, and tenderness over the injured ligament. In determining the nature of the injury, the knee is hyperextended and comparison is made with the normal knee, as lateral play is often present in those with congenital relaxation of the joint. In the normal knee there should be no lateral motion or rotation when the limb is in complete extension. If abduction is excessive, the internal lateral ligament is impaired; if adduction is increased there is impairment of the external ligament. External rotation may be increased when there is relaxation of the internal ligament, and internal rotation when there is relaxation of the external ligament. When the acute symptoms subside, in addition to the mechanical defect, there is a persistent tenderness over the insertion of the ligament into the tibia, femur, and head of the fibula and a feeling of disability and weakness in the knee. There may be a sudden flexing or giving way, or a slight catching within the joint, but rarely locking, unless associated with displacement of the cartilages.

Treatment.—Following recent rupture or injury of the ligaments, the knee should be maintained in complete extension for three or four weeks. Apparatus should be removed daily for massage and physiotherapy, but active and passive movement of the joint should not be permitted. At the end of four weeks a brace is applied, which prevents hyperextension and lateral motion, and should be worn for at least three months. Physiotherapy and well-directed exercises of the quadriceps extensor and flexor muscles must be continued until normal muscle tone is restored. If the point of rupture can be definitely located immediately after injury, incision and suture may be indicated. In those receiving efficient treatment immediately after trauma, an excellent result with restoration to normal may be expected in the majority of cases, but in those neglected or in those not responding to treatment, and in whom symptoms and disability persist, operative measures should be instituted. In relaxation following rupture of the lateral ligaments, the procedure devised by Edwards should be employed, the technic of which is as follows:

Edwards Technic.—External Ligament.—A straight lateral incision is made exposing the fascia lata, the tendon of the biceps, the lateral condyle of the femur, and the head of the fibula. A rectangular flap 3 inches long is raised from the fascia lata with its base at the femoral condyle. This flap is folded and sutured to form a strong narrow tube of fascia. A flap, also about 3 inches in length, is raised from the biceps tendon. The area on the lateral condyle where the ligament is normally attached is exposed and a small cavity $\frac{1}{4}$ inch in depth by $\frac{1}{2}$ inch in length is made in the vertical axis of the limb. A similar cavity is made on the head of the fibula. The biceps flap is inserted into the groove on the lateral condyle and retained there with a small staple. The flap of fascia lata is turned down, inserted into the cavity on the head of the fibula, and maintained in position by a staple. Both flaps are fixed in position while under strong tension, and a few stitches are placed to reinforce their attachments. The deep fascia is closed and the skin sutured.

Internal Ligament.—A straight incision is made on the medial aspect of the knee, exposing the sartorious muscle from the lower end of its fleshy belly to the tendon close to its insertion. By blunt dissection the tendons of the gracilis and semitendinosus muscles are exposed. Both these tendons are divided at the level of the medial condyle, dissected from their attachments and pulled forward. A groove is made on the medial condyle of the femur, at the point of normal attachment of the ligament, and the tendons are fixed in the groove with a staple.

The proximal end of the gracilis and semitendinosus tendons are sutured to the sartorius so that active contractile function of these muscles is not lost. The deep fascia is sutured and the skin closed. A plaster cast is applied to immobilize the limb for two weeks, after which massage is employed.

Rupture of the Crucial Ligaments

The anterior crucial ligament may be injured by the same forces that cause derangements of the internal cartilage; the posterior by the same mechanism that causes damage to the external cartilage. Extreme torsion may rupture both crucial ligaments and very severe trauma with hyperabduction, adduction, and torsion may rupture all ligaments permitting subluxation or complete dislocation. When the anterior crucial ligament is ruptured, the tibia can be glided forward and hyperextension is increased upon the femur. When the posterior ligament is ruptured the tibia can be glided backward upon the femur, and when both crucial ligaments are ruptured the tibia can be glided forward and backward upon the femur. In addition, there may be increased lateral movement and rotation, as the lateral ligaments are often impaired by the same injury. The spine of the tibia is occasionally avulsed or fractured with injury to the crucial ligaments, especially the anterior. Injury to the posterior ligament is possibly the cause of a type of loose body known as osteochondritis dissecans, which is sequestrated from the internal condyle of the femur near the attachment of the posterior crucial ligament. When the anterior crucial ligament is involved there is tenderness over the spine of the tibia, when the knee is flexed, which can be elicited by pressure on the inner side of the patellar tendon. If the posterior ligament is involved there is tenderness just below and to the inner aspect of the lower extremity of the patella, when the knee is flexed. Rupture of the crucial ligaments is also accompanied by a feeling of insecurity, giving-way, and slight locking, as when the lateral ligaments are injured, but differentiation can always be made by the points of tenderness and mechanical manifestations described. Weakness of the quadriceps muscle is often caused by reflex inhibition in all knee joint injuries and materially increases the feeling of instability, thus forming a vicious cycle.

Treatment.—The conservative treatment of rupture of the crucial ligaments is similar to that of rupture of the lateral ligaments, by prolonged immobilization in a splint or cast. Operative measures for the repair of the crucial ligaments are very rarely indicated as rupture is either repaired by nature or compensated for in a majority of cases. However, if necessary, the procedure devised by Groves should be employed.

Groves Technic.—Anterior Crucial Ligament.—A large U-shaped incision is made in front of the knee, the lowest part of the incision being just below the tubercle of the tibia, which is chiseled off. The patella is turned upward after cutting through the capsule and synovial membrane of the joint. The knee is now flexed, the joint explored and the rupture of the anterior crucial ligament demonstrated. A strip of fascia lata 8 inches long and $1\frac{1}{2}$ inches wide is secured with its base attached to the head of the fibula. A drill hole is made through the external condyle of the femur; the opening on the side being placed as far back as possible on the outer aspect of the intercondylar notch. The front part of the tibia is then drilled in a similar manner so that the inner aperture lies just in front of the tibial spine, and the external orifice is over the most prominent part of the inner tuberosity of the tibia. The strip of fascia is pulled through the hole in the femur and then passed through the hole in the tibia. This leaves about 3 inches of the free end projecting from the inner tuberosity of the tibia. The free end is then pulled taut, passed up the most prominent point on the inner aspect of the inner condyle and sutured while the knee is flexed. The capsule of the joint is sutured by a few interrupted catgut stitches. The tubercle of the tibia is fixed to its original bed by two bone or ivory nails and the skin is closed.

Posterior Crucial Ligament.—The first stage of the operation up to the point of full exposure of the joint cavity is the same as that for the repair of anterior crucial ligament. Strips 6 inches in length are cut from the semitendinosus and gracilis tendons, the distal ends being isolated and brought down and the proximal ends sutured to the semimembranosus muscle. A strong pair of artery forceps is then thrust backward through the inner part of the posterior ligament of the knee between the posterior horn of the meniscus and the head of the tibia. The two tendon strips are pulled forward by the forceps until their free ends project into the front of the joint. A hole is bored through the inner condyle of the femur in such a manner that it opens as far forward as possible on the inner aspect of the intercondylar notch. The tendons are piloted through this hole and pulled taut while the knee is fully extended. The free ends are turned downward, attached to the inner aspect of the inner tuberosity of the tibia, and the joint closed.

Hypertrophic Villi

Hypertrophic villi are caused by any persistent irritation from repeated injury or disease of the joint. The villi become elongated and enlarged, and may form lobulated masses, the so-called lipoma arbo-

rescens. The symptoms are a giving-way, or definite locking, which is only momentary, and is evidently due to slight impingement. There may be more or less effusion within the joint. The pain is usually on the mesial aspect with tenderness just below and to the inner side of the patella. Symptoms characteristic of the etiologic process inducing enlargement of villi may also be present. The diagnosis can not be made with certainty without exploration, as the enlarged villi may be the result of some other internal derangement, which is itself the cause of the symptoms.

Treatment.—The treatment must, of course, be directed to the active etiologic factor. The local treatment should be conservative by physiotherapy and a brace, such as is employed in internal derangement of the cartilages. In exaggerated cases, operative measures are indicated. An incision is made along the inner border of the quadriceps tendon and the joint is inspected. There may be observed cicatrization of the offending villi, or hemorrhage into the villi if impingement has been recent. Frequently, there may be no other abnormality than the enlarged fatty villi. Those which by their size and length may possibly be caught between the articular surfaces should be removed, and if the joint capsule is distended or relaxed, an elliptical segment of the capsule should be excised. A careful search should be made for other abnormalities before excising the villi, as other agents may have induced the symptoms.

Hypertrophy of Infrapatellar Fat Pad

Hypertrophy of the infrapatellar fat pad must be viewed in the same light as hypertrophy of the villi, and the symptoms are quite similar. Slight pain and tenderness are present just below the patella on either side of the patellar tendon. All derangements are more frequent on the inner than on the outer side, as the mechanism which induces trauma to the inner side of the joint is of more frequent occurrence. The symptoms may be sufficiently severe to warrant excision of the pad.

Loose Bodies

Loose bodies in joints composed of bone or cartilage, or bone and cartilage, are so apparent that they have probably been recognized from time immemorial. There are two affections in which loose body formation is the outstanding symptom. These are (1) osteochondritis dissecans, or the sequestration of masses of bone from the articular surface into the joint cavity; (2) osteochondromatosis or synovial enchondroma. There are also certain other conditions in which loose bodies

occur, such as (3) the formation of processes of new bone and cartilage, which are broken loose within the joint, in certain joint affections, as ostearthritis; (4) the organization of clots of fibrin forming rice bodies and melon-seed within the joint; (5) fractures of the articular surfaces.

Loose bodies are observed more frequently in men than in women. Phemister collected 196 cases from the literature, of which 182 were males and 14 were females. The age of onset varies with the etiology, but on the whole, is more frequent in late adolescence and early adult life, and comparatively rare after middle age. The knee is affected in 90 per cent and the elbow is next in frequency of occurrence. In a large percentage only one joint is involved, though loose bodies may be occasionally bilateral.

Fig. 194.—Osteochondritis dissecans. Note triangular area of rarefaction on medial condyle of femur surrounding small area of increased density.

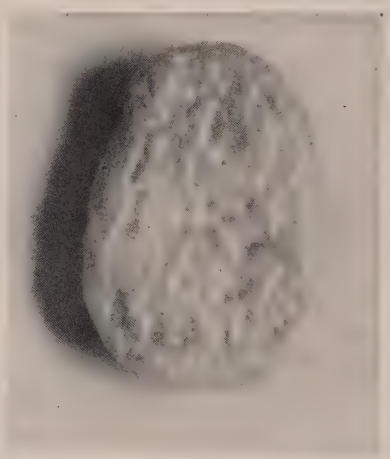


Fig. 195.—Loose body removed from knee in osteochondritis dissecans.

Osteochondritis Dissecans.—The term "osteochondritis dissecans" was applied by König to a condition in which bone fragments of varying sizes separate from the articular surfaces.

Etiology.—Osteochondritis dissecans is an affection of adolescence and early adult life, and is rare in middle age and almost unknown in old age. Males are more frequently affected than females, the percentage being approximately fifteen to one. There is a wide divergence of opinion as to the etiology of osteochondritis dissecans, the various theories of which may be enumerated as follows: (1) Traumatic; (2) embolic; (3) constitutional.

Traumatic Theory.—Trauma may act in three ways: (*a*) By direct force at the point of greatest contact; (*b*) by direct pull on the anterior attachment of the posterior ligament; and (*c*) by injury to the arterial supply. Practically all observers agree that trauma is a predisposing causative agent and many contend that trauma is the sole cause. However, from the history of definite injury in a large percentage, and the fact that trauma may damage the insensitive articular surfaces and superficial bone without causing symptoms, trauma must be regarded as an important etiologic factor. The only possible argument against the traumatic theory is the presence of localized symptoms prior to the formation of a loose body.

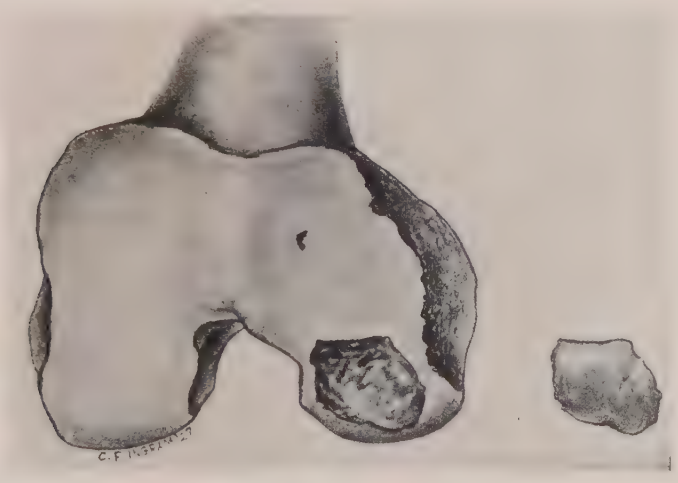


Fig. 196.—Osteochondritis dissecans with body detached from articular surface of internal condyle of femur.

Embolic Theory.—Rieger believes that fat embolism may follow trauma. As the medial genicular artery, which is thought to supply the affected region of the femur, lies in fatty tissues in adults, this is particularly true in adults, but not in children, which may explain the nonoccurrence of the condition in children. Axhausen, from examination of certain allied conditions, believes that bacterial embolism may be a causative agent.

Constitutional Theory.—Low-grade arthritis, or local ostearthritis, has also been considered a cause of loose body formation. Ely states that this is a predisposing cause, but admits that trauma is coexistent. Freiberg and Woolley considered the condition a possible variant of arthritis deformans. No evidence of an infectious process has yet been observed, and foci of infection apparently have little in-

fluence. Also the joint itself is practically normal and there is much less associated pathologic change than might be expected. Fromme suggests some constitutional or inherent abnormality as rickets, fragilitas ossium, coxa vara, etc., as the causative agent. Axhausen regards it as similar to coxa plana. Phemister suggests the same etiology as that causing ununited fractures.

Pathology.—Osteochondritis dissecans usually occurs in the knee at the point of greatest impact, namely, the lateral portion of the surface of the internal condyle adjacent to the intercondylar notch. In the elbow, the capitellum is invariably the point of occurrence of osteochondritis dissecans, which is thought to be due to forcible abduction with pressure of the rim of the head of the radius against the capitellum. The occurrence of the condition in the elbow is second in frequency only to that in the knee, the incidence in the knee being about 90 per cent.

After direct trauma, indirect trauma, circulatory disturbances, or other causative agents there gradually separates from the affected area a somewhat conical shaped mass of bone. The process of separation may require months or years, during which time slight or no abnormality may be apparent in the joint. When the line of cleavage has been formed between the body and the surrounding bone, thus separating the body entirely, it falls into the joint cavity. After becoming loose in the joint the body may be ground into several pieces, and a larger number of bodies formed, each of which may continue to increase in size. While retained in the osseous cavity the articular surface of the body is convex and invested by hyaline cartilage, the deep surface is irregular and invested by fibrocartilage. The smaller bodies within the cavity may be composed entirely of cartilage. Rarely the retained bodies may become reunited to the parent bone with spontaneous restoration to normal, or the loose body may become attached to synovial villi or folds of ligaments. Prior to being expelled into the joint the body may project above the surface and cause irritation. After expulsion the bodies become rounded, and after remaining in the joint for a long period of time, the hyaline cartilage may become fibrous, and there may be evidence of necrosis, especially in the deeper cells, or there may be marked proliferation of the cartilage with increase in size. The central bone, when present, may be living or in various stages of necrosis, and blood vessels are, at times, found within the bone. Cartilage may proliferate in an irregular manner, forming cauliflower or mulberry-like bodies of varying sizes. There may be areas of calcification, which may become arranged in layers separated by fibrocartilage, forming the so-called laminated bodies, which are more common in synovial osteo-

chondroma. The tendency of loose or unattached bodies is to degenerate in the interior and become necrotic, and to proliferate on the exterior, which probably indicates that there is sufficient nourishment in the joint fluid to supply superficial cells and induce proliferation.

Symptoms.—The symptoms of loose bodies are largely mechanical; they become caught between the joint surfaces, thus causing sudden pain and weakness of the joints, which, at times, may become blocked. The body is usually involuntarily released by reflex muscular activity of the patient with relief of symptoms. After such an attack there may be a definite reaction to mechanical irritation within the joint, as shown by swelling or articular effusion. Symptoms of loose bodies, as a rule, are not so severe as those of deranged semilunar cartilages. Repeated attacks may induce organic changes of the joint structures but rarely of an extensive degree. Prior to separation of the fragment or fragments of bone, pain of a dull aching character may be experienced, with at times slight effusion or swelling, which may closely resemble the onset of a low-grade inflammatory process, and not infrequently the diagnosis may be made by characteristic manifestations demonstrated by the roentgenogram. Before the general use of the roentgen ray, the diagnosis was impossible until the loose body had separated and typical symptoms of impingement between the joint surfaces were experienced, or detection was made by palpation.

Roentgenoscopy.—The roentgenogram is pathognomonic and, as a rule, will show the body and also the defect in the articular surface from which the body arose. In the knee joint the origin is usually the medial condyle of the femur. On the surface of the condyle there is a punched-out irregular triangular notch of varying size. The body, if not completely detached, may be seen lying in the cavity and separated from the underlying bone by a definite clear-cut line of demarcation. If the body is detached, it will appear as an oval shadow in the joint.

Treatment.—Obviously, when definite symptoms are present, the treatment of all loose bodies is removal by free incision into the joint cavity. In osteochondritis dissecans, not only must the bodies be removed, but the interior of the osseous cavity must be well curetted, so that all loose material is removed down to the bone. All overhanging margins of cartilage or bone must be trimmed flush with the articular surfaces, otherwise, recurrence is probable, as has frequently been reported.

Osteochondromatosis (Synovial Chondroma or Osteochondroma).—Osteochondromatosis is a rare pathologic process in which pedunculated or loose bodies are formed within the joint cavity from the synovial

membrane. Synovial osteochondromas are also found rarely in bursa and tendon sheaths in close proximity to the joints. The chondroma and osteochondroma are probably of neoplastic origin.

Etiology.—Synovial chondroma or osteochondromatosis occurs more frequently in males than in females. Jones reports 19 cases, of which 16 were males and 3 females. The age of incidence is more advanced than in loose bodies from osteochondritis dissecans. Synovial chondromas are usually monarticular, affecting more frequently the knee; rarely there is a bilateral involvement. The cause has not been definitely

Fig. 197.—Osteochondromatosis with multiple loose bodies in knee joint. Anteroposterior view.

Fig. 198.—Same as Fig. 197. Lateral view.

proved and there are, at the present time, three accepted theories: (1) infectious; (2) traumatic and (3) neoplastic.

Infectious Theory.—Reichel, Wheloche, Carothers, Kappis, and others have suggested that osteochondromatosis may arise in an infected joint or may be complicated by an infection of the joint. However, a distinction must be made between osteochondroma associated with ostearthritis and osteochondromatosis occurring independently.

Traumatic Theory.—Trauma occurs with sufficient frequency to be given a prominent place as a causative agent. However, in the reported

cases the proportion in which there is a definite injury is not so great as in osteochondritis dissecans.

Neoplastic Theory.—The embryological development of cartilage cells suggests the possibility of a metaplastic tissue proliferation in the synovial villi, and the various stages in the development of the bodies as demonstrated by the microscope, also strongly support the neoplastic theory. In all probability, from the evidence available, trauma inducing cell growth and benign osteochondroma must be considered a frequent combination.

Pathology.—There may be only one large loose body, or there may be great numbers, even a thousand have been removed from a single

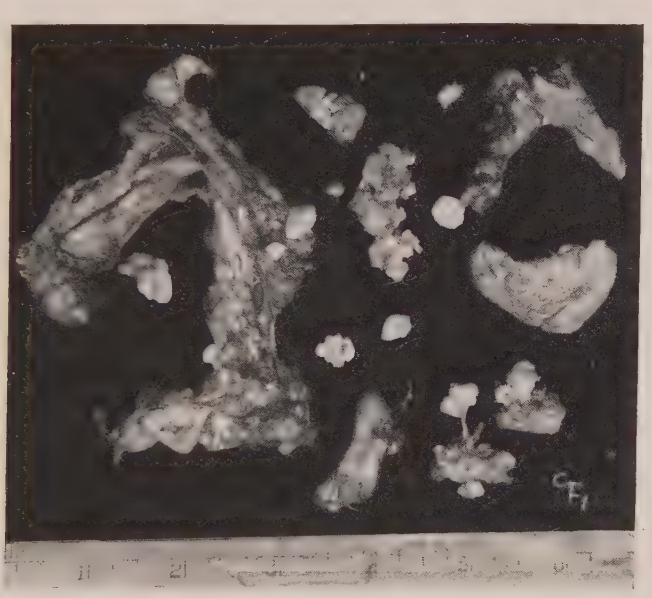


Fig. 199.—Specimen of synovial membrane from osteochondromatosis showing multiple free and attached bodies.

joint. The bodies vary in size from that of a small shot to 4 or 5 centimeters in diameter. They may be oblong, somewhat rounded, kidney-shaped or cauliflower-like from proliferation of superficial cartilage. When in contact with the synovial membrane, the opposing surface becomes smooth and convex, while the unopposed surface is rough. When many bodies are packed in a recess of the joint, facets may be formed by pressure of the bodies against each other.

The tips of many villi are found to contain teatlike processes of cartilage or bone. The body in the villus may be developed from this teatlike process or a large portion of the villus may be involved. By

gradual evolution, a mature body may be formed, composed of a capsule of fibrous tissue beneath which is fibrocartilage running superficially parallel with the surface. In the deeper layers, the cartilage cells are arranged more or less perpendicular to the surface and resemble hyaline cartilage. In the deep layers, there may be areas of calcification. The interior of the body may consist of bone, fat cells are abundant between the bone trabeculae, and there may be an invasion of cartilage and fibrous tissue. Blood vessels which communicate with the pedicle and villi may also be observed. The entire mass is an organized and living body. Many of the attached bodies do not reach such a high state of development. Some are composed of almost pure bone, some of fibrocartilage with or without spicules of bone within the interior. In many, the circulation from the pedicle is deficient or impaired by thrombosis, which causes degenerative and necrotic changes within the interior. The bodies may become detached and free within the joint cavity, and as in bodies derived from osteochondritis dissecans, there is every evidence of growth or increase in size, and the superficial tissue is not only living but proliferative.

Symptoms.—The symptoms depend on the number and size and the mechanical action of the bodies. If large or multiple and there is extensive involvement of the villi, abnormalities may be detected by palpation. The joint motion may be only slightly restricted. Crepitation may be detected and apparent to the patient on active and passive motion. In those with extensive involvement the bony landmarks may be obliterated.

Roentgenoscopy.—The roentgenogram demonstrates the numerous osteocartilaginous bodies closely packed within the joint and completely filling and distending the joint capsule. The articular surfaces, as a rule, are normal, unless they have become eroded through pressure of the bodies.

Treatment.—In osteochondromatosis, the treatment is surgical with removal of the loose bodies. In those with extensive involvement of the synovia an excision of the synovial membrane may be necessary. If the posterior compartment of the joint is invaded, posterolateral and posteromesial incisions may be required in addition to the incision into the anterior compartment.

Detached Osteophytes.—Loose bodies may be observed as a complication in many affections of joints. In ostearthritis there may be excessive proliferation about the periphery of the articular surfaces with the formation of osteophytes. One or more of these processes may be broken loose in the joint by direct trauma, or this may occur without

trauma. These bodies are usually pyramidal in shape and if observed early, will show a raw bony surface at the point of fracture; later there will be a thin layer of fibrocartilage incrusting this region, and the surface of the body is composed of fibrocartilage. The treatment should be directed chiefly toward elimination of foci of infection, with physiotherapy and other measures described for the treatment of osteoarthritis. If the loose bodies are all large and causing symptoms by mechanical irritation, they should be excised, but the removal of the loose bodies does not always give complete relief.

Organized Fibrin.—Coagulation of fibrin may produce small bodies known as melon-seed, or rice bodies. These are formed in the course of degenerative processes and have no influence on the pathology. The roentgenogram does not show such bodies but does reveal the pathologic process which is the causative agent. The diagnosis is made by physical examination when the bodies can be palpated. The removal of loose bodies caused by necrotic tissue is of secondary importance, but when necessary, the operation is carried out as for other lesions within the joint.

Fractures of Articular Surfaces.—Direct or indirect trauma may fracture a particle of cartilage or bone, which may fall free within the joint cavity. Such fractures may be caused by ligamentous pull or by impaction through indirect force, or by direct force over the articular ends. Such injuries are usually followed immediately by definite symptoms of pain, swelling, and impairment of function, or the symptoms may be delayed for several days or weeks after the injury. The roentgenogram will usually demonstrate and locate the fragment. In a majority of cases these particles become reattached or absorbed without inducing organic changes. Large masses, as the condyle of the femur and portions of the tuberosities of the tibia at the knee and head of the femur within the hip joint, are often described as loose bodies, but in reality are gross fractures. If, in the judgment of the surgeon, the presence of the fragment will cause mechanical injury, arthrotomy is indicated immediately after the fracture, with removal of the detached particle. In those observed later, when mechanical interference is apparent, incision and removal are imperative; otherwise, further organic changes may impair joint function.

BIBLIOGRAPHY

Axhausen, G.: Die Entstehung der freien Gelenkkorper und ihre Beziehungen zur Arthritis deformans, Arch. f. klin. Chir., 104:581, 1914.

Axhausen, G.: Zur Entstehung der freien Solitarkorpen des Kniegelenks, Deutsch. med. Wchnschr., 46:825, 1920.

Campbell, Willis C.: Extra-articular Fusion of the Sacro-Iliac Joint, Surg., Gynec. and Obst., 45:218, 1927.

Campbell, Willis C., and Mitchell, J. I.: Semilunar Cartilage Cysts, Amer. Jour. Surg., 6:330, 1929.

Edwards, A. H.: Operative Procedure Suggested for the Repair of the Collateral Ligaments of the Knee-Joint, Brit. Jour. Surg., 8:266, 1921.

Ely, L. W.: Joint Mouse, Ann. Surg., 61:80, 1915.

Fisher, A. G. Timbrell: Internal Derangements of the Knee-Joint, New York, Macmillan Co., 1924, p. 6.

Freiberg, Albert H., and Woolley, Paul G.: Osteochondritis Dissecans; Concerning Its Nature and Relation to Formation of Joint Mice, Amer. Jour. Orthop. Surg., 8:477, 1910–1911.

Fromme, A.: Die Bedeutung der Looserschen Umbauzonen fur unsere klinische Auffassung (Os acetabuli and Gelenkkorper), Arch. f. klin. Chir., 116:664, 1921.

Gibney, Virgil P.: Sprained Ankle, New York Med. Jour., 61:193, 1895.

Groves, Ernest W. Hey: The Crucial Ligaments of the Knee-Joint; The Function, Rupture and Operative Treatment of the Same, Brit. Jour. Surg., 7:505, 1920.

Jones, Hugh T.: Loose Body Formation in Synovial Osteochondromatosis with Special Reference to the Etiology and Pathology, Jour. Bone and Joint Surg., 6:407, 1924.

Jones, Robert, and Lovett, Robert W.: Orthopedic Surgery, New York, William Wood and Company, 1923, p. 33.

Kienboch, Robert: Über traumatische Malazie des Monddeins und ibre Fol gezustande: Entartungsformen und Kompressions frakturen, Fortschr. a. d. Geb. d. Rontgenstrahlen, 16:77, 1910–1911.

König, F.: Ueber freie Korper in den Gelenken, Deutsch. Ztschr. f. Chir., 27:90, 1887–1888.

Kümmell, H.: Ueber traumatische Wirbelerkrankung, Deutsch med. Wchnschr., 21:180, 1895.

Phemister, D. B.: The Causes and Changes of Loose Bodies Arising from the Articular Surface of the Joint, Jour. Bone and Joint Surg., 6:278, 1924.

Rieger, H.: Zur Pathogenese von Gelenkmansen, München. med. Wchnschr., 67:718, 1920.

CHAPTER IX

DISLOCATIONS

A DISLOCATION is a separation or change in relation of the articular surface of the bones comprising a joint. The terminology indicates that the distal bone is separated from the proximal bone, for example, dislocation of the shoulder means the displacement of the humerus on the scapula. The term *luxation* is applied when the displacement is complete; *subluxation* denotes a partial separation of the articular surfaces. Bilateral or double dislocations of corresponding joints may rarely occur, and also multiple dislocations of several joints less frequently. Total dislocation is the complete separation of a bone at both extremities, as displacement of the humerus at the shoulder and elbow. Avulsion of an extremity is the traumatic amputation through a joint. Dislocations are more frequent in males than in females.

Traumatic dislocations may be subdivided into: (*a*) Acute dislocations; (*b*) recurrent or habitual dislocations, and (*c*) unreduced dislocations.

ACUTE TRAUMATIC DISLOCATIONS

Etiology.—Acute traumatic dislocations are induced by direct or indirect violence or by muscular contraction. Direct force applied to a bone separates the articular surfaces of the bones, ruptures the ligaments, and displaces the joint. When the dislocation is caused by direct violence, there is great injury to the surrounding soft tissues and usually a complete severance of all ligaments retaining the articulation. Dislocation by indirect violence is a displacement produced by the leverage action of the dislocated bone. This is the most frequent form of dislocation, and the shoulder is dislocated more often than any other joint. The articular surface of one of the bones comprising the joint is forced against the capsule, which ruptures at this point, the other portions of the capsule remaining intact. The capsule is thus penetrated by the articular surface and the joint is completely separated or dislocated. Muscular action plays a part in every dislocation by indirect violence, for when the articular surface is forced out of the joint there will be a sudden contraction of muscles further aiding the displacement. The extremity of the bone remains for a short time opposite the rent in the capsule, this location being called the primary position; soon the

bone is further displaced by muscular contraction to a secondary or permanent position where it remains until reduced.

Rarely, dislocation by muscle pull alone may occur by sudden unbalanced contracture of the muscle about a joint, as in dislocation of the shoulder by throwing a ball. Deficient anatomical development of a joint and fractures of the articular surfaces may be predisposing factors in such dislocations. The contraction of the muscles in spasms, as epileptic convulsions, may also produce dislocations. The majority of acute traumatic dislocations are simple or closed; open or compound dislocations are those in which the displaced articular extremity of the bone penetrates the surrounding soft structures and skin.

Symptoms.—The symptoms of traumatic dislocation are: (1) pain of a sickening or nauseating character; (2) immobility of the joint caused by reflex muscular spasm; (3) loss of function; (4) alteration of contour of the joint; (5) change in relation of the bony anatomical landmarks or prominences; (6) palpation of the head of the bone in a new and abnormal position; (7) absence of the bone from its normal location; (8) variation in length of the extremity.

A systematic examination of joints should be made subsequent to all injuries, as is customary in injuries of other organs of the body. After a complete history of the injury, a routine examination of the patient will demonstrate the contour of the joint by inspection. Swelling may frequently obscure the bony prominences in displacements of the long bones. By palpation, abnormalities in relation of the articular surfaces may be detected, and by passive motion, crepitation may be apparent which is much softer than that elicited between the fragments of a fractured bone. The position of the dislocated extremity of the bone may also be determined by palpation and passive movements. Passive motion is usually greatly limited and painful; the range may be free for several degrees, but the movement is often more limited in certain directions than in others. Active motion may not be possible or is limited to a few degrees. Mensuration may demonstrate that the length of the limb is either increased or decreased, depending upon the type of dislocation; for example, in obturator dislocations of the hip joint the limb is usually increased in length; in dorsal dislocations it is decreased. In the extremities, the integrity of the nerves and blood vessels should always be ascertained, at the first examination, and a notation of their condition made in the record.

Complications.—1. The most frequent complication is a sprain fracture caused by the tearing loose of a portion of bone with the attachment of a ligament or the avulsion of a fragment of bone by the

insertion of a tendon. Not infrequently intra-articular ligaments and structures are displaced or lacerated, as the semilunar cartilage and crucial ligaments of the knee.

2. Gross fractures may be associated with dislocations, as fracture of the neck of the humerus, in dislocation of the shoulder, and fracture of the upper third of the ulna in dislocation of the head of the radius.

3. Nerve injuries are not infrequent and vary from slight neuritis, due to contusion or stretching, to complete severance of the nerve. In dislocation of the shoulder and hip, injury to the brachial plexus and sciatic nerve, respectively, not infrequently occurs. Traumatic neuritis may persist for an indefinite period regardless of the type of treatment employed.

4. Impairment of circulation is a serious complication though fortunately quite rare. Marked anemia indicates arterial obstruction, and usually denotes impending gangrene of the extremity, while cyanosis is a symptom of interference with venous circulation.

5. Dislocation may induce an extensive reaction within the joint causing a persistent traumatic arthritis. The articular surfaces may become destroyed and the joint may be painful with restriction of motion.

6. Stripping of the periosteum, severance of tendons, and displacement of muscles or tendons are more uncommon; when the periosteum is torn, new bone may form, bridging the joint, or there may develop in the surrounding muscles or soft parts a localized myositis ossificans.

7. Infection is a rare complication of a closed dislocation, and occurs only following very severe trauma by direct force, when the entire capsule and surrounding soft tissues are macerated.

8. Injury to viscera may occur, as rupture of the bladder, in separation of the symphysis pubis, and the crushing of the spinal cord in dislocation of the spine.

Diagnosis.—The diagnosis of traumatic dislocation is made from the history of injury, associated with the other symptoms. If there is much swelling, however, the diagnosis may not be possible without the roentgenogram. Roentgenograms should always be made when feasible, to determine any complications which may be associated, as well as the relation of the dislocated surfaces. In many instances, however, the patient is in agonizing pain, or there may be impaired circulation or nerve injury. In such conditions, a reduction can often be made without anesthesia by certain manual passive movements. In all cases, roentgenograms should be made after reduction to confirm the position, and under no circumstances should manipulation be applied unless the

surgeon is reasonably certain of the diagnosis, as disastrous results often occur in attempts to reduce when the condition is a fracture, and no dislocation is present.

Treatment.—In traumatic dislocations, reduction should always be accomplished as early as possible. The same forces applied in a reversed direction to that which caused the dislocation are required to reduce the displacement. Direct force, indirect force by leverage, and the elimination of muscular action by anesthesia are usually necessary. When the diagnosis is self-evident and the dislocation occurs at a place inaccessible to the roentgen ray, as on a football field, reduction without making a roentgenogram is often permissible. Dislocations are often reduced by a comrade before the patient is observed by the surgeon.

Methods of reduction differ with the anatomy of the individual joints; manipulations well planned to replace the dislocated joint surface should be made, but always without undue force. If reduction can not be accomplished manually, operation is indicated. Failure of reduction is no reflection upon a surgeon, but a gross fracture unnecessarily produced is a disgrace. Also, if care is taken in reduction by avoiding excessive or blind force, such complications as nerve injury and impairment of circulation will be avoided. In many uncomplicated dislocations, reduction may be accomplished without anesthesia, but if there is muscular resistance, deep anesthesia is required. After reduction, passive and active motion is instituted as early as possible by the aid of apparatus which will prevent dislocation. Careful observation is required but displacement may be avoided if ordinary care is taken. When the dislocation has been produced by indirect violence, the dislocated articular surface is made to retrace its route by intelligently applied force. The articular surface is brought opposite the rent in the capsule. Replacement usually occurs with an audible snap, after which passive movements may be carried out in all directions. When the dislocation has been caused by direct violence, all the ligaments are severed and the reduction is usually accomplished by direct force, the articular surface being approximated with ease. However, approximation is maintained with difficulty and longer immobilization is required to permit healing of the lacerated ligaments and soft tissues surrounding the joint.

Treatment of Complications.—Fractures complicating dislocations often require special consideration, unless reduced when the articular surfaces are approximated. Leverage can not be made to secure reduction, and therefore open operations may be the only means of reducing the dislocation and approximating the fragments. Loose particles of

bone, tendons or other structures may so interfere with reduction that replacement is impossible without open incision. Serious nerve injury is rare and is manifested by paralysis or persistent neuritis. If no improvement occurs after a reasonable time, exploration of the nerve is indicated. A longitudinal incision may be made into the nerve sheath, with removal of scar tissue which constricts the nerve, and in those instances when the nerve is severed, nerve suture is required. Exploration is indicated early, and is not employed as frequently as it should be, for the procedure is simple, without risk and may accomplish much good. Impairment of circulation requires immediate attention. If, after reduction, the color has not improved by relief of the pressure, the limb should be elevated a few minutes. If there is still no improvement and gangrene is impending, exploration of the blood vessels is indicated. Surgery of the blood vessels is a difficult problem in the hands of the average surgeon. Suture of large arteries may be attempted, but, as a rule, amputation is required, unless collateral circulation is restored by nature after ligation.

Traumatic arthritis may ensue and be of such severity as to impair function materially; operative measures, as arthroplasty, or even fusion of the articular surfaces may be required before relief from pain can be secured. Infection after closed reduction requires incision and drainage with measures to combat or to restrain the progress of the infection. In open or compound dislocations the wound and the entire joint should be thoroughly cleansed with ether before reduction. Débridement may at times be required. When the wound can not be cleansed, reduction is accomplished and drainage is instituted down to but not within the joint. Virulent infections are treated along the same principles as those occurring elsewhere in the body. Myositis ossificans and masses of bone, such as extra-articular bridges, may be excised with material improvement in function after there has been complete organization. Dislocations of each joint will be described, beginning with the toes and following the skeletal system from below upward.

Traumatic Dislocations of the Foot

Phalanges.—Dislocations of the phalangeal joints are usually caused by hyperextension of the toes by violence acting in an upward direction, as "stubbing" of the toes. The toes are dislocated onto the dorsal aspect of the foot, the inferior capsule is ruptured, and the head of the phalanx or the metatarsal bone often penetrates through the rent in the capsule. Reduction can be accomplished in most instances by direct traction. If not, the toe is hyperextended and downward

pressure made over the dorsal aspect of the dislocated phalanx. The toe is then plantarflexed which causes the displaced fragment to slip easily into position with a definite snap. If replacement can not be accomplished by manual movements, an open operation may be necessary.

Metatarsal Bones.—Dislocation of the metatarsal bones at the tarsometatarsal joints is caused by direct or indirect violence. The forefoot may be crushed by the weight of a heavy object, or the foot may be caught and fixed as between the planks of a walk and the dislocating force be generated by the patient's body as it lunges forward or backward. Dislocation of the first and fifth metatarsal bones may be upward or downward; the first metatarsal bone may also be displaced

Fig. 200.—Dorsal dislocation of first metatarsophalangeal joint.

inward, and the fifth outward. Dislocation of the three remaining metatarsal bones may be upward or downward, but is more frequently upward. The symptoms are pain and alteration of the contour of the foot by swelling and the actual osseous displacement. When the first metatarsal bone is displaced, the inner border of the foot is shortened. Reduction is usually accomplished by traction and rocking motion of the foot; when reduction is not possible manually, an incision is necessary when, with a blunt instrument, the articular surfaces may be approximated.

Tarsal Bones.—Dislocation of a single tarsal bone may be partial or total, uncomplicated or complicated by fracture, or there may be displacement of the bone at mediotarsal and subastragalar joints. Dislocation of the cuboid bone as a complete or total dislocation is un-

known. Dislocation of any one of the cuneiform bones may occur, or all three may be dislocated together. The displacement is upward and inward, and can be determined by palpation of the displaced bone on the dorsum of the foot. When the entire group is dislocated, reduction may often be accomplished by traction upon the great toe and direct pressure over the displaced bones. If this fails, open reduction is indicated. When one cuneiform is displaced, the question arises as to whether reduction or excision is the treatment of choice. If the bone is reduced, atrophic changes may follow from impaired circulation or a persistent traumatic arthritis may develop. In either instance pain and disability may continue for an indefinite period. If excision is carried out, practically no disability follows, and good function is usually restored in a much shorter time. Total dislocation of the scaphoid is practically always upward and is brought about by force through direct pressure of the astragalus, as in falling on the sole of the foot from a considerable height. The head of the astragalus descends downward and inward, producing a marked degree of flatfoot which is called traumatic flatfoot. As reduction may rarely be accomplished, excision gives the best practical result, after which the foot is placed in a cast for four weeks. When weight-bearing is allowed, an arch support should be applied and worn constantly in the shoe for at least six months. Physiotherapy and muscular exercises should be continued for an indefinite period to restore function. In those in whom pain persists, the head of the astragalus should be fused to the cuneiform bones and the calcaneocuboid joint arthrodesed.

Mediotarsal Dislocations.—A mediotarsal dislocation is a double dislocation of two joints, the astragaloscaphoid and the calcaneocuboid. The cause may be indirect or direct violence, as forcible hyperextension or hyperflexion of the mediotarsal joint. The separation begins with a rupture of the astragaloscaphoid capsular ligament, after which both joints are dislocated. In dorsal displacements, the foot is shortened; the head of the astragalus and the anterior extremity of the calcaneus can be palpated on the sole of the foot, while the displaced cuboid and scaphoid bones can be outlined on the dorsum of the foot. In plantar dislocations, the head of the astragalus and the anterior extremity of the calcaneus can be palpated on the dorsum of the foot.

Reduction, often accomplished by traction leverage and direct pressure over the head of the astragalus, should be performed immediately as permanent damage to the tendons and ligaments may result. If reduction can not be accomplished by manual methods, an incision is made over the external lateral aspect of the foot and a blunt elevator

or bone-skid introduced between the head of the astragalus and the scaphoid, prying the articulation into position. Replacement of the calcaneocuboid joint occurs simultaneously. If, after the swelling subsides, there is an incurrent flattening or depression of the longitudinal arch, a plaster cast should be applied, with the arch held in the normal or slightly exaggerated position. The cast is worn for six weeks, when a steel arch support is placed in the shoe and weight-bearing instituted. Weight must not be placed upon the foot until the integrity of the longitudinal arch has been completely restored. This usually requires from six to eight weeks; often exercises to cultivate power in the tibial and peroneal muscles are required.

Fig. 201.—Dislocation of tarsal bones at mediotarsal joint. Anteroposterior view.

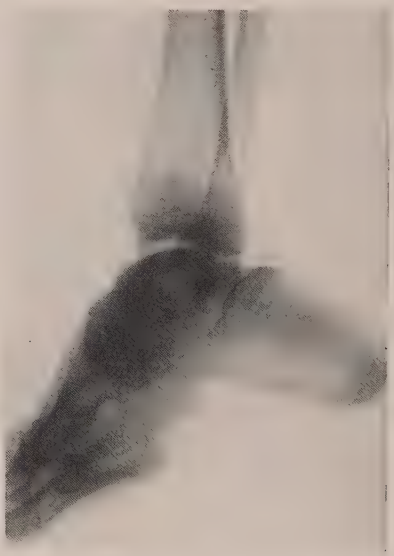


Fig. 202.—Same as Fig. 201. Lateral view.

Subastragalar Dislocations.—Subastragalar luxation is a complete displacement of the foot from the astragalus, not only at the subastragalar joint, but at the astragaloscaphoid and the calcaneocuboid joints as well. The diagnosis of subastragalar dislocation is made by finding the relations of the malleoli to the astragalus normal while their relations to the other tarsal bones are changed. Flexion and extension of the ankle joint are usually free. Movement below and anterior to the astragalus is usually restricted, but if there has been extensive ligamentous laceration, normal motion may be increased. Reduction is accomplished easily, with the knee flexed, by traction upon the forefoot

or heel and direct pressure in the direction necessary to secure normal approximation of the articular surfaces. Open reduction is seldom necessary and the results after uncomplicated dislocations are excellent. The swelling subsides by the end of two to three weeks when a Gibney adhesive dressing, as for a sprained ankle, is applied and walking instituted. If infection occurs, however, this complication is a serious one and amputation may be required.

Traumatic Dislocations of the Ankle

Dislocation of the astragalus from the tibiofibular mortice, or pure ankle joint dislocation, uncomplicated by fracture, is very rare. Forward

Fig. 203.—Lateral dislocation of ankle. Anteroposterior view.

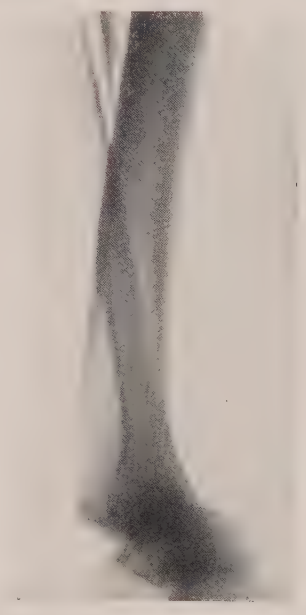


Fig. 204.—Same as Fig. 203. Lateral view.

luxations are caused by forcible hyperextension or plantar flexion of the forefoot, while the heel is fixed or by forced upward pressure upon the plantar surface. Backward dislocations may be caused by forcible hyperflexion of the foot while the leg is fixed. Outward and inward dislocations are always complications of fractures of the tibia or fibula, or fractures of both bones. Upward dislocations of the ankle are a great rarity, and consist of upward displacement of the astragalus between the tibia and fibula with a complete diastasis of the lower extremities of the two bones. Reductions of uncomplicated dislocations of the ankle are usually accomplished with ease; when fractures are associated, ap-

proximations of the fragments must be secured. If the astragalus is grossly fractured, it should always be removed.

Traumatic Dislocations of the Distal Tibiofibular Joint

Dislocation of the lower tibiofibular joint is a diastasis by rupture of the tibiofibular ligament just above the ankle joint. Reduction is easily accomplished by traction upon the foot and lateral pressure over the lower extremity of the fibula. A roentgenogram should be made to confirm the reduction, as a permanently defective ankle is to be expected, unless close apposition of the bones is obtained.

Traumatic Dislocations of the Proximal Tibiofibular Joint

Dislocation of the upper tibiofibular joint is rare, but may be caused by direct violence, as a blow over the upper extremity of the fibula, or indirectly by a sudden inversion of the foot and a twisting of the leg. The contraction of the biceps femoris muscle may cause direct traction on the head of the fibula into which its tendon is inserted. Dislocations may usually be replaced with ease by direct pressure, but as the articular surfaces are flat, maintenance in the reduced position is sometimes difficult. Rarely open operation may be necessary. A transplant of fascia lata may be placed through drill holes in the head of the fibula and adjacent surface of the tibia. The fascia is drawn taut and sutured with No. 2 chromic catgut; silver wire, a beef bone peg or a nail through the head of the fibula into the tuberosity of the tibia may also be employed.

Traumatic Dislocations of the Knee

The knee is involved in pathologic and traumatic processes more often than any other joint in the body, but complete separation of the articular surfaces requires the severance of many strong ligaments by great force and consequently dislocation of the knee is rare. A sudden force against the leg may force the tibia to glide forward or backward, or a similar force against the thigh may displace the femur. Indirect forces act by hyperextension of the knee while the leg is fixed, as in the lunging forward of the body when stepping into a hole, the sudden dropping of an elevator, or twisting the leg in a moving wheel or belt. The tibia may be displaced in one or four directions; anteriorly, posteriorly, externally, or internally. Anterior dislocation is the most frequent.

Anterior Dislocations.—In anterior dislocations the knee will be extended and fixed unless there is undue laceration of the soft tissues. The calf of the leg lies on a plane anterior to that of the posterior sur-

face of the thigh. The upper extremity of the tibia and the patella can be palpated anteriorly. Posteriorly, the skin is tense, but the hamstring tendons may be palpated, as well as the condyles of the femur which lie in the popliteal space. Pulsation of the anterior and posterior tibial arteries may or may not be palpable, depending on obstruction to the circulation. Numbness, loss of sensation, and paralysis may be present if there is injury to the tibial or common peroneal nerves.

Posterior Dislocations.—Complete posterior dislocation of the tibia is less frequent than anterior dislocation. Incomplete posterior dislocation may be observed following rupture of the posterior crucial

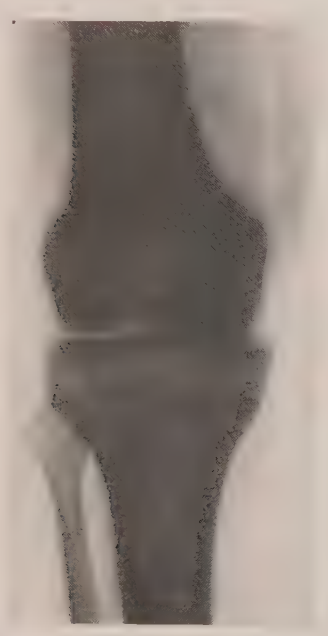


Fig. 205.—Anterior dislocation of knee. Anteroposterior view.

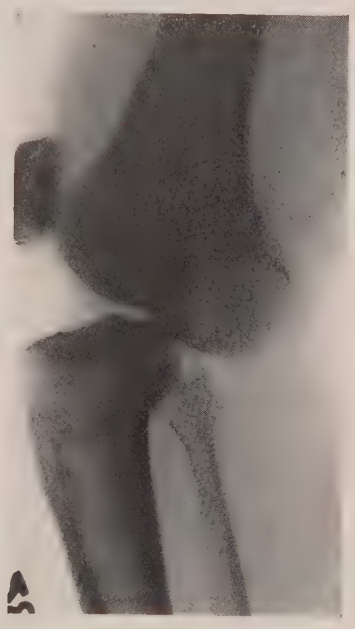


Fig. 206.—Same as Fig. 205. Lateral view.

ligament, and may be caused by direct or indirect violence; the nerves and vessels may also be injured. In posterior dislocations the knee is slightly flexed; the lower extremity of the femur can be palpated anteriorly and the upper extremity of the tibia in the popliteal space; the patella may be displaced to the outer or inner side, or may lie in the space between the condyles. The skin over the front of the knee is tense. The leg is on a plane posterior to that of the thigh, but may be deflected to one side or the other. The tibia is above the lower extremity of the femur, causing a decrease in length of the leg which may be as much as 3 inches. If some of the ligaments are intact, there

may be more or less ridigity, but considerable motion may be present if all the ligaments are torn.

Lateral Dislocations.—Dislocations of the knee laterally may be towards the external or internal aspect. External luxation of the knee is caused by forcible adduction. The tibia is displaced outward and its inner tuberosity is in contact with the outer condyle of the femur. The leg may be either abducted, adducted, or parallel to the thigh, but is always on a plane lateral to it. Internal dislocations of the knee are

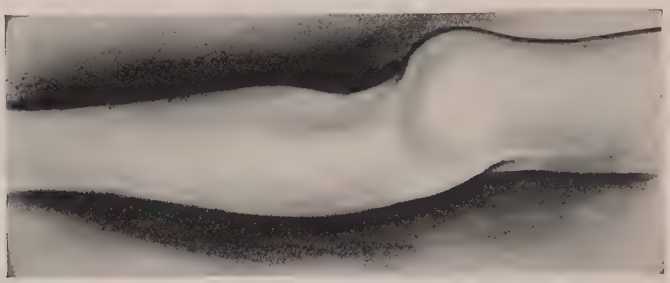


Fig. 207.—Backward dislocation of knee. Anteroposterior view.

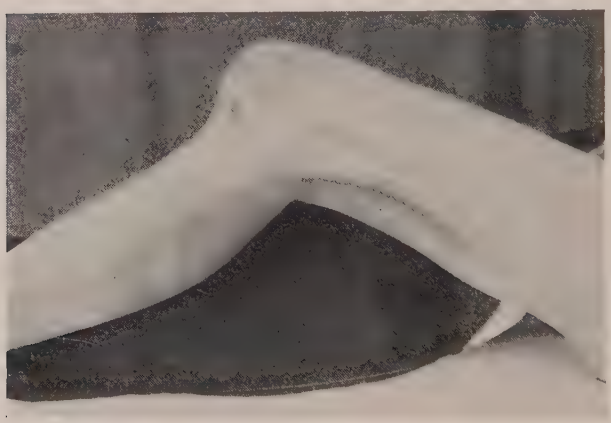


Fig. 208.—Same as Fig. 207. Lateral view.

the reverse of external dislocations and are less frequent. The popliteal vessels are often injured.

Treatment.—Reduction may be indicated before roentgenograms can be made because of impending injury to the circulation and the nerves. Reduction is usually accomplished easily by manual traction and direct pressure over the upper extremity of the tibia. In anterior dislocations, the knee must not be further hyperextended as this will place greater tension on the stretched vessels and nerves. After reduc-

tion, the tendency to redislocation is prevented by a gutter-splint or cast conforming to the shape of the leg with the knee slightly flexed. Continuous traction should be avoided as the extensively lacerated ligaments may become permanently elongated inducing an unstable joint. Operation may be required frequently and when gangrene develops from impairment of circulation, amputation is necessary.

Traumatic Dislocations of the Patella

Traumatic luxation of the patella is of common occurrence, being next in frequency to dislocation of the shoulder. There are certain

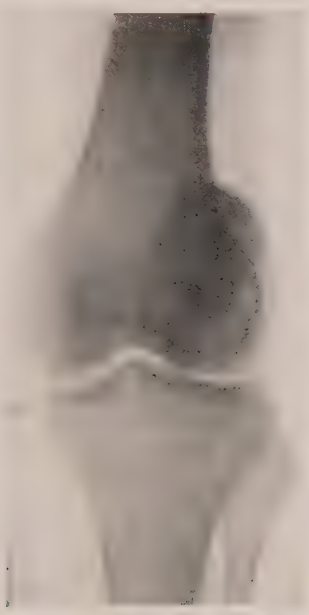


Fig. 209.—Dislocation of patella.

Fig. 210.—Dislocation of patella.

anatomical variations of both congenital and acquired origin which undoubtedly predispose to dislocation of the patella: (1) Genu valgum or knock knee changes the alignment of the limb and throws the pull of the quadratus femoris muscle external to its line of normal action. Thus a constant strain is placed upon the inner capsule of the knee, producing relaxation of the capsule which allows the patella to slip outward. (2) The patellar tendon may be inserted to the outer aspect of the normal position which permits the same action as knock knee. (3) The articular surface on the posterior aspect of the patella is divided into two portions by a vertical ridge. The outer is broader and slopes normally from without inward and backward at an angle of

45 degrees. At times the inclination of this surface may be decreased and the corresponding surface on the femur may be flattened. Thus, an outward displacement is rendered more probable. Inward displacement is prevented by the elevation of the internal femoral condyle with a correspondingly greater slant of the opposing articular surface on the posterior aspect of the patella. The actual cause of dislocation is direct violence or muscular action, or to a slight extent indirect violence. Direct violence acts by a blow or pull upon the patella, aided by abduction of the knee joint. Muscular action when the knee is flexed and abducted, with the muscle acting at a defective angle, may dislocate the patella. Dislocations of the patella may be classed as: (1) External, which is by far the most frequent; (2) internal, which is so rare as to be almost unknown; (3) inferior, superior, and backward, which can only occur after the tendon ruptures. The dislocation may be complete or incomplete, rotary, or reversed.

External dislocations may be incomplete when the patella slides only partially outward, but does not slip entirely over the outer border of the lateral condyle, a portion of the articular surfaces remaining in contact. In complete dislocations the patella is displaced external to the lateral condyle, the articular surface facing backward and inward. Rarely the patella may be rotated in the line of its long axis as it passes over the highest portion of the condyle. This rotation may be partial or total until the posterior surface may face directly forward, the quadriceps tendon being twisted. In complete dislocations there is usually a longitudinal tear in the internal capsule, unless there is abnormal relaxation of the capsule. The tear is parallel with the patella and may extend for several inches, involving the vastus internus muscle. The internal lateral ligament may be torn; there may be various types of internal derangement—chip fractures and trauma to the articular surfaces. On examination, the knee is slightly flexed, the anatomical contour of the lower extremity of the femur is apparent and there is a depression or dimple in the skin internal to the patella. The patella can be palpated external to the lateral condyle. In rotary displacements the contour and position of the patella can be palpated and the posterior surface may be outlined just under the skin. On deep palpation a definite rupture in the capsule may be found, if the examination is made before swelling occurs and the joint is distended from hemorrhage.

Reduction is quite simple, and may often be accomplished without anesthesia. The knee is extended and inward pressure made upon the patella, which, in many instances, may be easily replaced by direct pressure. The hip is first flexed to relax the quadriceps tendon. In

rotary displacements, the patella may be rotated gently into a simple outward dislocation and then reduced. In those with excessive increase of joint fluid, aspiration should be done before an attempt is made to reduce the dislocation. In reversed dislocations and in resistant cases, an open incision may be required; reduction is easily accomplished after the quadriceps muscle is untwisted. The rent in the capsule should be repaired with reefing of the margins. The after-treatment consists of complete immobilization for four weeks, after which a brace is employed to prevent lateral movements and to limit joint action for one or two months; muscle function should be cultivated. If care were taken with every acute traumatic dislocation of the patella, there would be comparatively few recurrences.

Traumatic Dislocations of the Hip

Traumatic dislocation of the hip is of rare occurrence in comparison with fractures of this region; in the aged, dislocations are almost unknown, as the force fractures the atrophic neck of the femur. Dislocations of the hip occur usually in young adults, more frequently in men than women, as is true of all traumatic injuries. Traumatic dislocations of the hip may be divided, for description, into (1) posterior; (2) anterior; (3) central.

Posterior dislocations are by far more frequent, and, according to the secondary position attained, may be subdivided into (*a*) high dorsal; (*b*) low dorsal; (*c*) everted dorsal, and (*d*) ischiatic. Posterior dislocations of the hip are more often caused by indirect violence or leverage by force from above, as a heavy weight falling upon the body, or by the force acting from below as when the patient falls from a height, but may be the result of direct violence, as crushing of the hip between two nonyielding surfaces. The mechanism of posterior dislocation is the same in the majority of cases. The hip is flexed, adducted, and rotated inward with great force, driving the head of the femur against the posteroinferior aspect of the acetabulum. The Y-ligament remains intact, as a rule, and acts as a fulcrum. The head descends, passes through the capsule at the lower posterior portion and, after dislocating, ascends upon the dorsum of the ilium, finding a secondary or permanent position at varying levels.

Symptoms and Diagnosis.—The physical signs of posterior dislocation are quite characteristic. The patient is unable to walk after the injury and the hip is held in flexion, adduction, and inward rotation. The trochanter is prominent and above the normal position; the gluteal fold is elevated. On palpation the absence of the normal resistance of

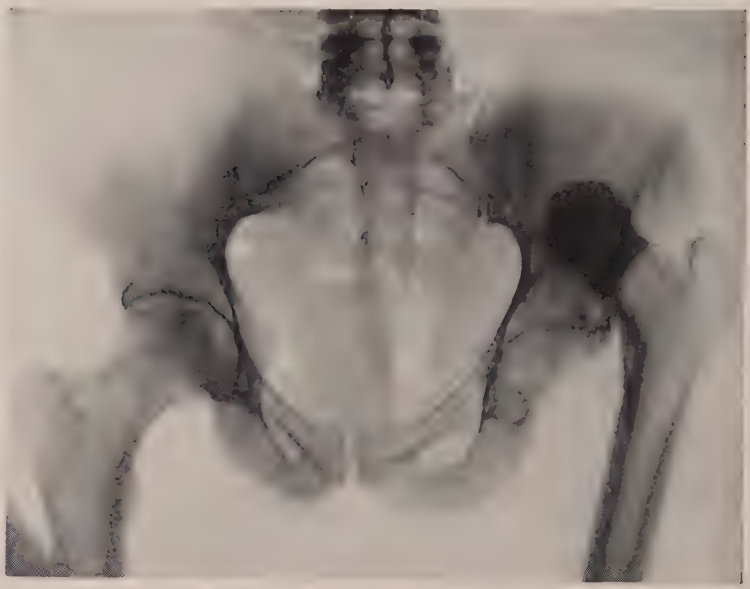


Fig. 211.—Dorsal dislocation of hip.

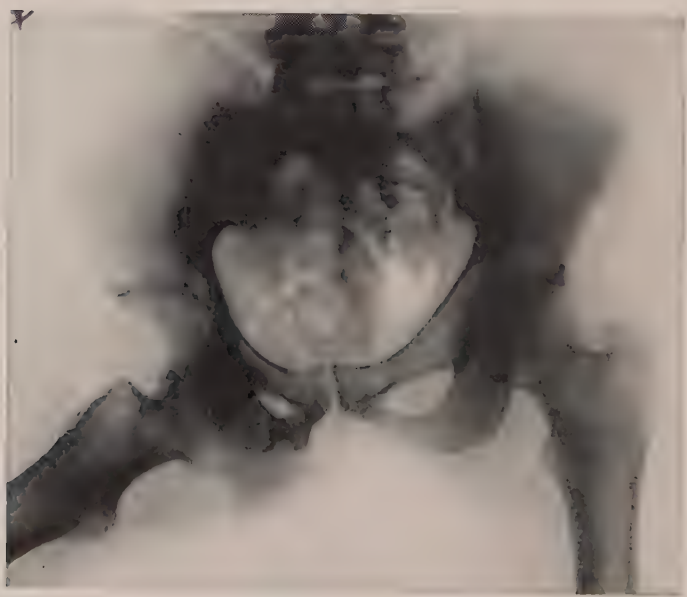


Fig. 212.—Obturator dislocation of hip.

the head of the femur in the center of Poupart's ligament can be detected. The trochanter is palpable above Nélaton's line and the head can be felt to move over the ilium on passive rotation, although the con-

tour can not be determined, except in very thin individuals. No active motion is possible and passive movements are restricted and painful. The length of the limb is not decreased as much as is apparent, except in the everted dorsal type; accurate measurements are secured with difficulty on account of the position of the limb. Crepitation is not present, unless the dislocation is complicated by fracture. Roentgenograms should be made of all hip joint dislocations and the exact relation of the articular surfaces determined.

The differential diagnosis between fractures and dislocations requires no special acumen on the part of the surgeon if he possesses

Fig. 213.—Obturator dislocation of hip.

Fig. 214.—Bilateral dorsal dislocation of hip. Note adduction and internal rotation of thighs.

even a superficial knowledge of the two conditions. The position, attitude, and physical signs are quite different, and the crepitation in fractures can usually be elicited. In dorsal dislocations the hip is flexed, adducted, and rotated inward; in central fractures of the neck of the femur the limb lies in extension and is rotated outward. Crepitation can also be elicited and the normal resistance of the head of the femur is present in fracture of the neck or trochanter. In the everted dorsal type of dis-

location there may be some slight resemblance to fracture, but the hip is flexed and everted and the leg usually extended. The age of occurrence should also be an aid in diagnosis. Prior to the use of the roentgenogram many errors in diagnosis were made, but now the roentgen ray will always differentiate the two conditions.

Treatment.—Reduction of dorsal dislocations of the hip is accomplished, as a rule, with ease. Traction in the line of deformity, the thigh being flexed, adducted, and internally rotated is usually sufficient; the head of the femur slips into the acetabulum with an audible snap. However, if this maneuver is not successful, there are three standard methods which have been devised, and which are as follows:

Allis Technic.—Complete anesthesia is usually required. The patient is placed upon a table or the floor and the pelvis is fixed by straps or by an assistant holding the crests of the iliac bones with both hands. Flexion of the hip in the line of the deformity is first increased, the thigh being adducted and internally rotated. The hip is then lifted upward and will usually slip into the acetabulum, after which extension can be made with ease; if there is resistance to extension, the hip should be redislocated, circumducted, and the maneuver repeated. Should resistance to extension of the limb persist, some structure is interposed between the articular surfaces, and an open incision is necessary so that all parts may be carefully inspected and a satisfactory reduction secured. The chief danger is that the obstruction may be the sciatic nerve which, if caught and traumatized, may result in a permanent paralysis of the leg.

Stimson Technic.—Stimson devised a method which has the advantage of not requiring anesthesia, although it may be employed with an anesthetic. The patient is placed face downward with both hips hanging over the end of a table. The unaffected limb is supported, in the extended position, by an assistant. The dislocated hip is permitted to flex by gravity to 90 degrees, and the leg is flexed 90 degrees at the knee. The ankle is supported by the surgeon while weights are placed upon the calf of the leg, making a gradual downward traction. In a few minutes the muscles relax and the head of the femur is replaced into the socket.

Bigelow Technic.—Bigelow's method consists of the same movements as the Allis method, with the addition of sudden abduction, external rotation, and extension of the hip, in other words, circumduction. Should the first attempt fail, the movements of flexion, internal rotation, and lifting are repeated when reduction is usually accomplished, as circumduction enlarges the aperture of exit in the capsule. When

there is a fracture of the posterior wall of the acetabulum, reduction may often be accomplished in the same manner, but traction is usually required to retain the head in the socket. A plaster cast is applied while traction is made on the leg. If reduction can not be maintained in this manner, a plaster cast is applied from the ankle to the nipple line and 30 pounds continuous traction applied to the thigh and leg.

Anterior dislocations of the hip are those in which the head of the femur is displaced anteriorly to the acetabulum and are much less frequent than posterior dislocations. Anterior dislocations, according to the position assumed by the head of the femur, are classed as (*a*) pubic; (*b*) obturator, and (*c*) perineal. The pubic dislocation is sustained by forcible abduction and hyperextension of the hip when a sudden weight falls upon the back, or when the patient lunges backward after stepping into a hole. The mechanism forces the head of the femur against the lower anterior portion of the joint capsule, through which it passes. The Y-ligament usually remains intact and acts as a fulcrum forcing the head forward until it rests upon the pubic bone. The vessels and anterior crucial nerve are pushed forward and are very rarely injured. The capsular ligaments of the hip are made tense across the acetabulum. The symptoms of pubic dislocations are characteristic. The hip is flexed, abducted, and rotated outward. The trochanter is less prominent and the head of the femur may be palpated just below Poupart's ligament. Active movements are impossible; adduction meets with great resistance. Traction and pressure upon the head will usually reduce the displacement; open reduction is rarely necessary. The obturator or thyroid dislocation and the perineal dislocation are caused by forcible flexion and abduction of the hip. The mechanism is practically the same as that of pubic dislocations, except that the position of flexion and abduction directs the head of the femur inward toward the obturator foramen and the perineum. Reduction is accomplished by traction in the axis of deformity and pressure upon the head of the femur in the direction of the joint. A canvas sling about the upper part of the thigh for making direct outward traction may assist in the reduction. Rocking movements may also be necessary. Open reduction may be required.

Central dislocation of the hip is the displacement of the head of the femur through the acetabulum into the pelvis, and is usually described under fracture of the pelvis, but accurate reduction is of far greater importance than in ordinary fracture of the pelvis. In fact, the integrity of the limb depends entirely upon the success of accomplishment and maintenance of the reduction. Two types may occur, the head may be

forced through the cotyloid notch or the bones forming the acetabulum may be split. Great force is required to produce this dislocation and the hip is usually in abduction. The pubic viscera, the bladder, rectum, or the iliac vessels may be injured. Such injuries are, of course, serious complications and often terminate fatally. The actual length of the leg may be decreased from 1 to 2 inches and the apparent length may be even more diminished by malformation. The head of the femur may become locked by the jagged fragments about the osseous aperture or the head may be retained in situ by muscular spasm. As the productive trauma is always severe, there is usually more or less shock. The mortality is reported to be about 50 per cent, but is not so high in uncomplicated cases. On examination, the trochanter, with the overlying skin, is depressed. The hip is adducted and externally rotated; active motion is completely restricted, passive motion is limited and painful. On passive motion there is crepitation, which distinguishes central dislocation from fracture of the neck of the femur, as in fracture of the neck there is no crepitation until the limb is rotated inward.

Treatment.—Reduction is accomplished by direct and lateral traction. A fracture table is almost a necessity. A strap may be placed about the upper aspect of the thigh for traction outward. Reduction can usually be accomplished but is often maintained with difficulty, there being a constant tendency for redislocation within the pelvis. The following method is simple and has been found most efficient. The reduction is accomplished, as described, after which adhesive traction is applied to the lower extremity, as for Buck's extension; a cast is applied extending from the ankle to the nipple line. The patient is placed in bed with 20 to 30 pounds of weight for extension, and the traction is continued for a period of four or six weeks. Skeletal traction by a weight and pulley attached to the trochanter may be employed and also direct skeletal traction by a pin or ice-tongs in the lower extremity of the femur.

Traumatic Dislocations of the Sacro-iliac Joint

Actual dislocation of the sacro-iliac joint, demonstrable by the roentgenogram, is exceedingly rare, and is caused by severe direct or indirect force, as crushing of the pelvis, falling, twisting of the body while the extremities are fixed, or during delivery, especially after artificial measures, as forceps and version. The sacrum is always displaced forward. The ilium is displaced upward and backward. The posterior ligaments may be elongated, but are very strong and are rarely completely ruptured. The sacral plexus which lies over the an-

terior aspect of the joint is frequently injured. Sacro-iliac relaxation, or sublaxation, is of doubtful occurrence. Certainly there is no proof of such a condition that is demonstrable by the roentgenogram, nor can motion in this joint be demonstrated clinically. The symptoms, diagnosis, and treatment of affections of the sacro-iliac joint have been discussed in the section on Traumatic Arthritis.

Traumatic Dislocations of the Spine

The Coccyx.—Dislocations of the coccyx may occur rarely uncomplicated by fractures; one of the small joints may be displaced or the

Fig. 215.—Dislocation of first lumbar vertebra.

articulation between the coccyx and the sacrum may be dislocated. The coccyx is most frequently displaced forward though dislocation to either side or backward is not uncommon. The dislocation may be caused by pressure during delivery, but more frequently by a fall upon the buttocks. The painful condition of the coccyx resulting from injuries to this region is known as coccygodynia. Women are more frequently affected than men, and patients suffering from coccygodynia are apt to be highly neurotic. The pain is aggravated by jarring, pro-

longed sitting, horseback riding, and defecation, and may be referred to the fifth sacral and coccygeal nerves. On palpation, undue motion, with pain, may be elicited. There is tenderness over the sacrococcygeal joint, and examination externally and by rectum may demonstrate dislocation of the entire coccyx, or some of its segments, or fracture with a tender nodule from overgrowth of bone. Directly after injury, reduction may be attempted by one finger in the rectum and external pressure with the other hand, but, as a rule, the reduction can not be satisfactorily maintained.

If pain persists, conservative methods of treatment, such as local applications and hot sitz baths, may relieve the symptoms when mild. In severer traumatic types the coccyx should be excised through a

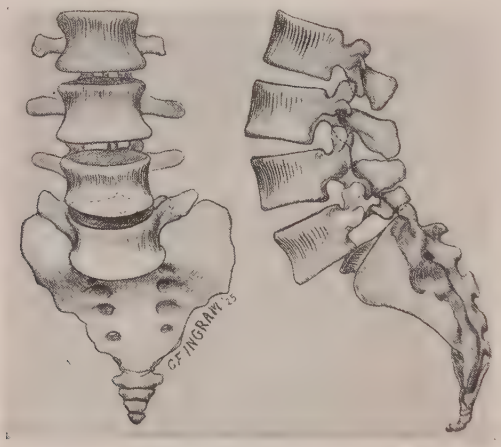


Fig. 216.—Spondylolisthesis with forward displacement of fifth lumbar vertebra on the sacrum.

midline incision, but distinction must always be made between the neurotic and traumatic types of coccygodynia, as operation is absolutely contra-indicated unless there is a history of definite traumatism.

The Lumbar Vertebrae.—Traumatic dislocations of the lumbar vertebrae are practically always complicated by compression fractures or multiple fractures about the margins of the bodies and tearing of the ligaments. Such injuries frequently cause crushing of the spinal cord or cauda equina in a manner similar to that produced by fractures of the lumbar vertebrae, and the treatment is also identical.

Spondylolisthesis is the forward dislocation of one or more of the vertebrae; the slipping of the fifth lumbar vertebra upon the sacrum is the most common displacement. The condition may occur in childhood, but is more often seen in early adult life.

Etiology.—Spondylolisthesis may be traumatic or congenital. However, as pointed out by Kleinberg, it is probable that in all cases there is a predisposing element, such as a developmental anomaly, and a direct cause, as trauma which, as a rule, is such as to cause forcible flexion of the spinal column. When the spine is thus strongly flexed, the articular processes of the fifth lumbar vertebra may be disengaged from the articular processes of the sacrum and the force acting from above, combined with the weight of the body, causes a forward displacement of the spine at the lumbosacral joint. Once the displacement has occurred, the impingement of the processes will effectually prevent the spontaneous reduction of the dislocation, and the body of the fifth lumbar vertebra glides forward and downward on the superior surface of the sacrum. The weight of the trunk is then sustained only by the muscles and ligaments of the spine. According to Ziegler, and others, when there is a congenital separation of the pedicles of the vertebra, the spinous process remains in the normal position, and the body of the vertebra is displaced forward.

Symptoms.—These consist of stiffness and soreness in the lower back and pain radiating about the iliac crests and down the legs, which is aggravated by exertion, such as prolonged standing or walking, jarring, lifting or stooping. Motor and sensory paralysis of the lower extremities may develop from the pressure or traction on the lumbosacral plexus. The objective findings are increase of the lumbar lordosis and a prominence of the sacrum. There is a depression immediately above the sacrum, but this is more apparent by palpation than on inspection. The pelvis appears to be more horizontal than normal; the anterior superior spines of the ilia are prominent, and the costal margin is closer than normal to the iliac crests. The spine is limited in motion in all directions, but especially so on forward bending; tenderness may be present over the lumbosacral or sacro-iliac joints, and Kernig's sign may be positive.

Roentgenoscopy.—The roentgenogram is typical and pathognomonic of the condition. Stereoscopic plates in the anteroposterior view are to be recommended as well as a good lateral picture. On examination of the anteroposterior roentgenogram in the stereoscope, the increase of the lumbar lordosis is apparent. The bodies of the upper four lumbar vertebrae are clearly seen, but the body of the fifth lumbar vertebra is superimposed upon the shadow of the sacrum. The oval outline of the body is visible with the spinal foramen open above it; the spinous process may be the most superior portion of the vertebra. In the lateral view, the bodies of the upper four lumbar vertebrae are seen placed one upon the other, their anterior surfaces forming an unbroken

line, slightly convex anteriorly. The fifth lumbar vertebra is displaced forward and downward on the sacrum.

Treatment.—The treatment of spondylolisthesis is supportive. Spinal braces and pelvic belts may relieve the symptoms, but unless complete relief is secured by such conservative measures, fusion of the lumbosacral joint is indicated.

The Dorsal Vertebrae.—Dislocation of the dorsal vertebrae is more often anteriorly; lateral and backward dislocations are very rare as the ribs prevent lateral displacement and the vertical articular processes backward displacement. Excessive trauma is required to produce lateral dislocation which may also be associated with fractures of the ribs and gross displacements; the injury is so severe and shock so great that death often ensues before the diagnosis can be made. The higher the site of dislocation in the dorsal spine the greater is the danger of serious complications by injury of the spinal cord with extensive paralysis. In those in whom the injury is above the ninth dorsal vertebra, the head is included in any fixation apparatus, while the thighs are not included, the apparatus terminating about the pelvis.

The Cervical Vertebrae.—Dislocation of the cervical spine may be unilateral or bilateral, and is usually associated with or complicated by fractures of the articular processes and also of the bodies of the vertebrae. Bilateral dislocation is the backward displacement of both articular processes of the vertebra below or a forward displacement of the vertebra above, and is hardly conceivable without fractures to other portions of the vertebra and irreparable injury to the spinal cord. Death often results immediately in bilateral dislocations, or the condition of the patient may be so grave that any attempt at conservative measures or reduction can not be considered. Unilateral dislocations are of more frequent occurrence, and unless complicated by gross fractures, do not often injure the spinal cord. Indirect violence inducing forced flexion or extension with torsion causes unilateral dislocation of the cervical spine, which may be complete or incomplete. The articular process above is displaced forward into the vertebral foramen just posterior to the vertebra below. The articular process above may rarely catch upon the top of the articular process below and remain in this relation with the dislocation incomplete, but more frequently passes forward and becomes complete.

Symptoms.—In unilateral dislocation there is a definite torticollis which resembles that of congenital wryneck. The neck is bent and shortened in the direction of the affected or dislocated side, while the chin is rotated in the opposite direction. The muscles on the dislocated

side are relaxed, while those on the elongated or opposite side are taut and spastic from stretching. Active and passive motion are more or less obliterated and there is often constant pain in the neck, and if there has been injury to the cervical nerves, there may be referred pain in the upper extremities. Dislocation between the atlas and axis does not cause as much deformity of the head and neck as dislocation of the other cervical vertebrae, but may be complicated by fractures of the odontoid process, or rarely this process may tear through the cervical ligament. In either case, there is usually serious injury to the spinal cord. Dislocation between the occiput and the atlas is extremely rare, causes only slight rotary displacement, and is difficult to diagnose. Pain in the upper extremities may not be noticeable until the elapse of several weeks, when a persistent neuritis with increasing pain may appear. This condition may persist and be aggravated to such a degree that partial paralysis of the extremities develops. Swelling or edema of the extremities is also a late complication, but in those treated early such complications do not arise. Often roentgenograms must be made from several angles to demonstrate the lesion.

Treatment.—Reduction may be accomplished by two methods: (1) the Wallton; (2) the Taylor. The Wallton method consists of manual reduction without traction. The sitting posture is preferred. The head is abducted to the side opposite that of the dislocation, and at the same time bent slightly backward. This lifts upward the dislocated articular processes and its fixation in the vertebral foramen is lessened. The head is then rotated to the affected side. There may be an audible snap and if no anesthetic is used relief will be instantaneous. The Taylor method consists of traction and might be called the traction method. Traction is made upon the head in the angle of deformity which separates the articular processes, and the head is then rotated in the opposite direction. This method is greatly facilitated by a fracture table. The lower extremities are fixed while the Sayre suspension apparatus is applied to the head. A canvas or heavy cloth material may be substituted for the leather apparatus; the ends of the bandages are attached to a belt which passes around the waist of the surgeon, who by his body can control the degree of traction necessary, and have his hands free to support and maneuver the head of the patient. After reduction is accomplished a plaster-of-paris cast is applied, extending from the lower ribs to the top of the head with an aperture for exposure of the entire face. When the dislocation is associated with fracture, the advisability of any manual movements of the head and neck is doubtful, as there is danger of further injury to the spinal cord, especially if the patient is under an

anesthetic; if paralysis exists, such manipulation may be cautiously employed after a laminectomy has been performed.

Traumatic Dislocations of the Temporomaxillary Joint

Dislocation of the temporomaxillary joint may occur during the acts of yawning, laughing, or chewing. Deficiency of the eminence of the temporal bone and relaxation of the capsular ligaments are predisposing causes. Dislocation of the intra-articular fibrocartilage may also be a predisposing factor. Uncomplicated dislocation is practically always anterior; outward, inward, and posterior dislocations are always associated with fractures of the base of the skull. Anterior dislocation may be unilateral or bilateral; bilateral dislocation is of more frequent occurrence. In bilateral dislocation, the chin is displaced forward, the mouth is open, a prominence can be felt just below the zygoma on both sides in the zygomatic fossa, and there is a loss of resistance over the normal locations of the temporomaxillary joints. In unilateral dislocation, the coronoid process is displaced forward with the articular surface. The chin is displaced forward and to the opposite side; there is loss of occlusion of the teeth and pain is usually constant. In both bilateral and unilateral dislocation the temporal muscles and the external lateral ligaments are made tense, locking the inferior maxilla in the displaced position. Reduction is accomplished under anesthesia. The surgeon stands at the head of the table and places his thumbs in the patient's mouth, making downward pressure over the molar teeth; the chin is lifted upward and forward by the remaining fingers of both hands. The coronoid processes slip into the articulation with ease and there is immediate relief.

Traumatic Dislocations of the Thorax

Dislocation of sternum may occur at two points; either the gladiolus or ensiform cartilage may be displaced from the manubrium. The gladiolus may be displaced anteriorly, in which case the anterior ligament is torn and a palpable protuberance appears on the anterior aspect. Reduction is accomplished without anesthesia, and consists in hyperextension of the spine, deep inspiration and backward pressure over the gladiolus. If reduction can not be accomplished by such methods, there are no serious consequences; however, the deformity can be reduced by an open incision, and in women, especially young women, such measures are obviously desirable. Backward or lateral dislocation of the ensiform cartilage may occur. Reduction may be accomplished by locking the fingers behind the process and pressing forward. However, this

may be difficult or impossible in large individuals or when the abdominal muscles are contracted. Rarely dislocation of the ensiform cartilage may cause persistent vomiting and in such cases excision of the cartilage may be easily accomplished by open operation.

Dislocations of the ribs from the costal cartilages and of the cartilages from the sternum may occur following direct trauma and dislocations associated with fractures of the ribs are also observed at the articulations with the spine. These dislocations may at times be reduced by deep inspiration and pressure over the displaced area; often, however, reduction in this manner may be impossible. After such injuries and, especially those involving the costal cartilages; strapping of the affected half of the chest is indicated and should be meticulously continued for a period of at least thirty days; otherwise there may be persistent pain. Rarely, the rib may be displaced for a considerable distance over the cartilage causing referred as well as local pain. The lower ribs are more frequently involved. There may be pressure upon the viscera or the ilium by an elongated twelfth rib, in which case excision of a portion of the rib is the only treatment.

Traumatic Dislocations of the Clavicle

Sternoclavicular Joint.—Dislocation of the sternal end of the clavicle may occur in any direction, but only the upward displacement is of sufficient frequency to warrant discussion. As a rule, perfect reduction can not be maintained on account of the contour of the articulation. Excellent function of the shoulder girdle is possible without reduction, but should disability persist, an open incision may be made and a strip of fascia or silk ligature passed through drill holes in the clavicle and sternum. The reduction is made and retained by tightening the internal suture. After reduction by the open or closed method, apparatus employed in the treatment of fractures of the clavicle is indicated.

Acromioclavicular Joint.—Dislocation of the acromioclavicular joint may be of three varieties: Supra-acromial, which is very common, and requires careful consideration, subacromial and subcoracoid, which are exceedingly rare. Supra-acromial dislocation of the acromioclavicular joint is caused frequently by falls on the shoulder, especially in athletics, during football games and in horseback riding. The dislocation is usually caused by direct trauma on the acromion process forcing the shoulder downward. The outer end of the clavicle is displaced upward so that it is quite prominent. The ligaments between the clavicle and the acromion process may be torn in mild cases, but in those of greater severity the coracoclavicular ligament is also ruptured and the upward dis-

placement is exaggerated. The roentgenogram of the shoulder when compared with the opposite side demonstrates the dislocation clearly.

Fig. 217.—Dislocation of acromioclavicular joint.

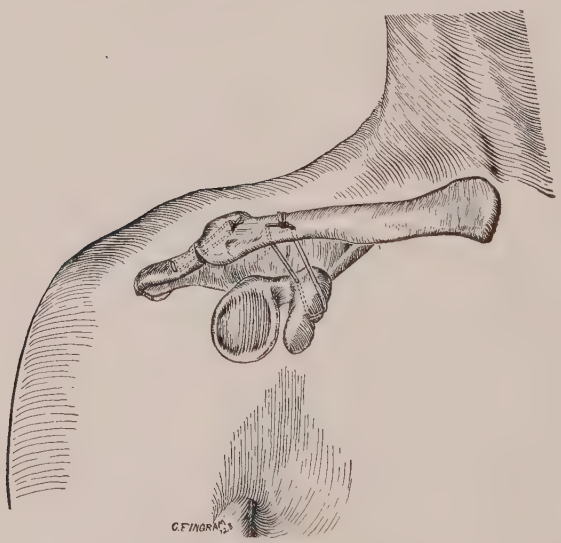


Fig. 218.—Method of repair of dislocation of acromioclavicular joint.

Treatment.—In mild cases simple adhesive strapping over the joint is effective. In many there may be practically normal function, even

though displacement persists. In those in whom there is definite impairment of function of the shoulder girdle, the operative treatment devised by Watkins offers an excellent chance of recovery. The coracoid process and acromioclavicular joint are exposed through an incision which begins along the outer inferior border of the clavicle and passes downward along the inner border of the deltoid muscle. A heavy braided silk suture is threaded through a hole drilled in the coracoid process and through two holes made in the distal end of the clavicle. This technic may be modified by passing the suture about the clavicle and under the coracoid process. The ends of the suture are tied tightly with intimate approximation of the acromion and clavicle; considerable tension is required if a perfect reduction is to be secured. The capsular ligament may be stitched, but this is of no consequence. The arm is immobilized for three weeks.

Traumatic Dislocations of the Shoulder

Dislocations of the shoulder are more frequent than those of other joints; this is obviously due to the greater range of motion in the shoulder joint. Shoulder joint dislocations may be classified for description as: (1) anterior; (2) posterior; (3) upward. The last mentioned is exceedingly rare and is associated with fracture of the acromion process. The mechanism of anterior dislocation of the shoulder is a lever action of the head of the humerus against the inferior margin of the glenoid cavity as the upper extremity is forcibly abducted. The head of the humerus is forced over the cotyloid ligament and through the antero-inferior aspect of the capsule. This area between the insertions of the subscapularis and the long head of the triceps muscle into the margin of the glenoid cavity is the weakest portion of the capsule. The head of the humerus, after passing through the rent in the capsule, reaches a point just below the coracoid process, causing a subcoracoid dislocation; if the force is greater, the head may be forced further mesially and lie just internal to the coracoid process, an intracoracoid dislocation. In some cases the head of the humerus may be forced still further inward and upward and reach a secondary or permanent position just below the clavicle when the dislocation is known as subclavicular. In rare instances the head of the humerus may become caught below the inferior surface of the glenoid fossa, and remain there as a subglenoid dislocation. When the abducting force is extreme, the head may be in the subglenoid position, but completely rotated until the superior surface of the head looks directly downward. This obviously can occur only when the upper extremity is completely abducted or erect above the head and the dislocation is,

therefore, called the "erecta" type. Dislocation of the shoulder may also occur by muscular action, as in throwing a ball. Dislocation by volition is also by muscular force, but is in reality an habitual or recurrent dislocation. Displacement by muscular contraction is probably caused by failure of coordination of the component muscles in certain movements so that the head of the bone is levered out of the socket.

Complications are numerous; tearing of the capsule, stripping of the periosteum, fractures of the greater tuberosity and avulsion of the separate muscles may occur. Rarely, the lesser tuberosity is avulsed by tension of the subscapularis muscle. The articular surface of the glenoid

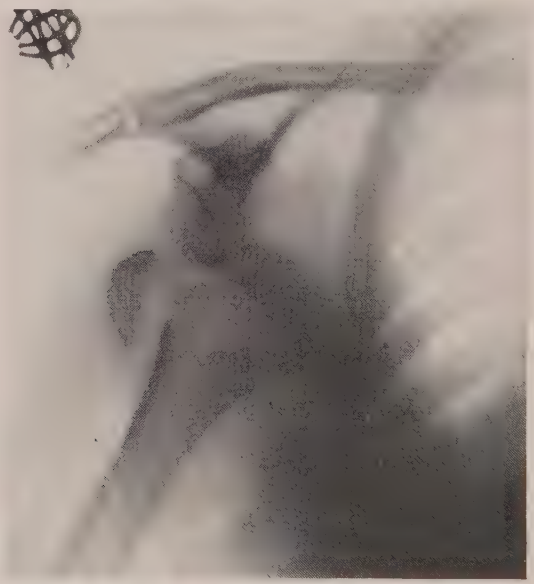


Fig. 219.—Subcoracoid dislocation of shoulder with fracture of the greater tuberosity of the humerus.

cavity may be injured; small fragments of bone and cartilage may be split off and the cotyloid ligament torn and displaced. The neck of the scapula is often fractured and the normal inclination of the articular surface altered so that the joint surface is directed downward at an increased slant. The greater tuberosity may be displaced outward or rarely may be fixed in the cotyloid cavity below the acromion process. The tendon of the long head of the biceps muscle may be displaced outward, interposed or even wrapped about the humerus after fracture of the greater tuberosity. Open dislocation is of rare occurrence but may follow extreme violence. There may be injury to the brachial plexus, the axillary nerve and rarely to the circumflex nerve which supplies the

deltoid muscle. The blood vessels may be compressed, completely ruptured, or the wall of the vessel may be contused, followed by aneurysm as a late complication.

Symptoms and Diagnosis.—The symptoms are pain, rapid swelling, and the anomalous position and relation of the parts. The position is quite characteristic; on inspection the arm is abducted, the elbow flexed and the weight of the arm supported by the opposite hand. The anatomical alignment of the shoulder is lower than normal, and there is a definite depression over the glenoid fossa with a loss of the normal contour of the shoulder; the acromion process and often the coracoid process are prominent. The position of the dislocated head may also be determined by inspection as a definite enlargement is visible. Palpation will elicit the position of the articular surfaces and is of great diagnostic value when there is excessive swelling. The roentgenogram will confirm the diagnosis and will disclose any fractures which may be present.

Treatment.—Reduction of dislocation of the shoulder is usually accomplished with ease and without complications, if proper care is exercised. The Kocher method has been devised to meet mechanical requirements and, when successful, is the best and safest procedure. The wrist is held by one hand, the elbow supported by the other, and the shoulder is very slowly and carefully rotated externally. The elbow is then lifted upward and brought across the chest in adduction, and finally the arm is rotated inward. External rotation widens the rent in the capsule and brings the head into position so that the other movements cause it to pass through the aperture into the socket. Steady outward rotation overcomes contraction of the pectoral and the subscapular muscles while adduction and the upward lift complete the reduction. The classical test of successful reduction is placing the elbow against the chest, while the palm of the hand rests upon the opposite shoulder. If dislocation is present the two joints can not be placed in the same plane.

Outward and downward traction constitutes the principles of numerous other methods. This may be accomplished by the heel of the surgeon in the axilla acting as a fulcrum, while downward traction upon the upper extremity is made by grasping the wrist. As great force may be applied, this method may induce serious complications by injury to the nerves and blood vessels; if employed with the same care as is used in other methods, reduction may often be accomplished after failure by the Kocher method. Outward traction may often be accomplished by a band about the humerus, by which traction is made by the surgeon while an assistant holds the extremity in adduction. In this manner direct outward pull is made upon the humerus. Direct traction may

also be employed by a method devised by Stimson which is similar to the gravity traction employed by him in dorsal dislocations of the hip. This method consists in placing the patient upon the side with the body supported on one table and the head upon another; the dislocated extremity hangs between the two tables. Weights of from 5 to 10 pounds are tied to the wrist and the patient remains in this position until muscle spasm is overcome, when reduction is accomplished.

In subglenoid dislocations outward traction with pressure on the head is usually sufficient. In erecta dislocations the heel of the surgeon is placed upon the upper aspect of the shoulder and traction made directly upward. Gross fractures will be produced if any forcible attempt is made to adduct the arm before reduction is accomplished. The after-treatment consists of immobilization in adduction for a period of a few weeks, after which function is gradually permitted, but complete abduction is not allowed for eight weeks. Many surgeons prefer immobilization by adhesive tape with the forearm across the chest. If the after-treatment were strictly carried out, there would be comparatively few habitual or recurrent dislocations. If complete reduction can not be made and there is evidence of interposition of tissue, an open exploratory operation is indicated. After every reduction a roentgenogram should be made to confirm the position.

Traumatic Dislocations of the Elbow

Dislocations of the elbow are of fairly frequent occurrence and are observed more often in males than females. Children, especially between the ages of eight and twelve, frequently dislocate their elbows. Dislocations of the elbow may be classified as follows: (1) Backward, (2) outward; (3) inward; (4) anterior; (5) divergent; (6) dislocation of the radius, and (7) dislocations of the ulna.

Posterior dislocation of the elbow is far more frequent than dislocation in any other direction and, consequently, is of the greatest importance. It is usually caused by falls upon the outstretched hand, the elbow joint being hyperextended and abducted. The impingement of the olecranon process in the olecranon fossa acts by hyperextension to separate the ulna and radius from the humerus. After the slight backward leverage, contracture of the anterior and posterior muscles causes further displacement backward and upward. Posterior dislocations may also be caused by falls with the elbow fixed by muscle contracture in flexion. This exerts a direct backward pressure from below along the long axis of the forearm. In posterior dislocations, the anterior ligament of the elbow is completely ruptured, as a rule, well below the

humeral attachment, so that a portion of the ligament falls between the dislocated surfaces. Both lateral ligaments are usually ruptured, the internal more extensively.

Symptoms.—The elbow is usually in a position of about 130 degrees flexion, or may be completely extended. There may be slight internal or external deviation. The forearm may be either supinated or pronated. The olecranon process is prominent posteriorly, and the triceps muscle stands out above the olecranon. There is an increase in the space between the olecranon and the condyles and the condyles are farther below the olecranon than normal. Active flexion is restricted; passive

Fig. 220.—Posterior dislocation of elbow. Anteroposterior view.

Fig. 221.—Same as Fig. 220. Lateral view.

motion may be carried out for about 30 degrees, but not beyond 90 degrees flexion. Rotation is very painful and restricted in active and passive motion. Lateral mobility is usually markedly increased.

Treatment.—Reduction is usually accomplished easily, first by hyperextension and then by direct traction upon the forearm. Pressure alone upon the olecranon process may be sufficient to push the olecranon directly into position. Flexion with downward traction upon the forearm, with or without a fulcrum, as the knee against the anterior aspect of the elbow, may be employed, but there is always danger of fracturing the lower extremity of the humerus which is a serious complication. In no case should undue force be applied. In those rare in-

stances in which the routine manual movements fail, suspension traction of about 10 to 15 pounds in children and 15 to 30 pounds in adults may be employed for twenty-four to forty-eight hours, when a second attempt at manual reduction may be made, which, in all probability, will be successful. The after-treatment consists of the applications of a splint which holds the elbow at about 60 degrees flexion, or simple adhesive strips with padding over the flexor surfaces may be applied to maintain the position. At the end of two or three weeks there should have been sufficient healing of the ruptured ligaments to permit active use.

Anterior Dislocations.—This is a rare form of dislocation and is thought to be due to a torsion force after falls upon the outstretched

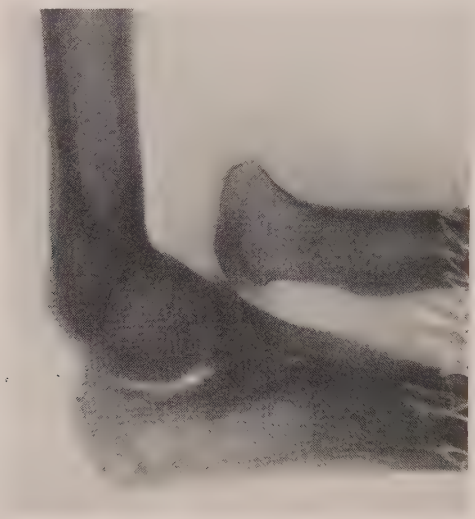


Fig. 222.—Dislocation of head of radius.

forearm, or a torsion force after external dislocation. The olecranon and head of the radius may be dislocated forward and lie on a plane anterior to the condyles of the humerus, or the upper extremity of the olecranon may approximate the trochlear surface of the humerus, causing an incomplete dislocation. Reduction is accomplished with ease by traction in the flexed position and downward pressure. In some instances the olecranon and sigmoid must be rotated about the outer aspect of the humerus before reduction is possible. The after-treatment is the same as that of posterior dislocations.

Lateral Dislocations.—In external dislocation, the elbow is flexed and the transverse diameter is apparently doubled. In internal dislocations the appearance is the reverse of external dislocation.

Head of Radius.—Dislocation of the head of the radius forward may be caused by direct violence upon the upper extremity of the radius as a blow from behind or by indirect violence, as a fall upon the hand. The orbicular ligament is ruptured or stretched, and the head of the radius usually penetrates the capsule. The dislocation is often associated with fracture of the shaft of the ulna. When the elbow is flexed, the relaxed capsule permits the head to descend so as to articulate with the capitellum, but when the elbow is extended, unless the head has receded within the capsule the dislocation recurs. The reduction may be accomplished by manual methods under the fluoroscope. If reduction is not maintained, open operation is necessary. An incision is made on the posterior aspect of the forearm over the head of the radius, beginning about 1 inch above the elbow joint. The fascia between the triceps and extensor carpi radialis longior muscles is incised, and the head is exposed, reduced, and, if possible, the orbicular ligament isolated and united. Often a strip of fascia may be dissected from the adjacent region and employed to fashion an orbicular ligament, or one may use a transplant of fascia lata.

Traumatic Dislocations of the Wrist

All dislocations of the wrist are anterior or posterior, but there are many variations of these two types. Dislocations of the lower end of the ulna uncomplicated by fracture is uncommon. Dislocation of the carpal bones is, on the whole, more often posterior. The semilunar bone often remains in position in dislocations of the wrist, while each opposing bone is displaced. This is due to the fact that the lateral ligaments are attached to the lateral aspect of the carpus and to each opposing bone and are much stronger than the interosseous ligaments uniting these bones to the semilunar. Fracture of the scaphoid bone which often occurs in injuries of the wrist is equally important and may complicate all dislocations of the carpal bones. In backward dislocations the appearance is similar to that of the classical silver-fork deformity of Colles' fracture, but the prominence of the displaced carpus is below the radius and can be palpated; also the anterior protrusion of the lower extremity of the radius and ulna may be apparent and can always be palpated. In forward dislocations, the conditions are reversed; there is a definite mass on the anterior aspect and the prominence of the lower extremity of the bones of the forearm on the posterior aspect. Reduction is accomplished with ease by simple traction and pressure over the displaced carpus, or a rocking movement may be required. Reduction must be confirmed by the roentgenogram, as frequently the reduction

may not be complete and other complications, as fractures of one of the bones of the carpus, especially the scaphoid, may be present.

Semilunar Bone.—Dislocations of any of the bones of the carpus may occur singly, but isolated dislocation of the semilunar is more frequent. The cause of the dislocation is usually indirect violence by falling on the outstretched hand. The bone is dislocated anteriorly and rotated about an arc of 90 degrees, coming to lie beneath the flexor

Fig. 223.—Dislocation of wrist. Anteroposterior view.

Fig. 224.—Same as Fig. 223. Lateral view.

tendons of the wrist where it causes pain and interferes with all movements of the wrist and fingers. The median nerve may also be involved by pressure, causing a persistent neuritis with pain and numbness in the hand. The diagnosis should be suspected from the history of an injury combined with limited function and symptoms of neuritis. A lateral roentgenogram of the wrist reveals the semilunar bone lying anteriorly to the rest of the carpal bones. If the patient is seen immediately after the accident, attempts may be made, either by closed manipulation or by an open operation, to reduce the dislocation, and may be

successful. After three weeks' duration, however, the consensus of opinion is that the semilunar bone should be excised through an anterior

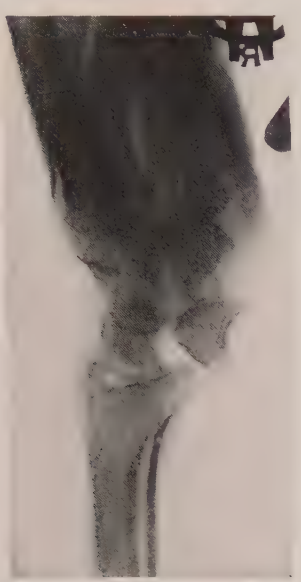


Fig. 225.—Dislocation of carpal semilunar bone. Anteroposterior view.

Fig. 226.—Same as Fig. 225. Lateral view.

median incision. The functional results following excision are usually excellent.

Traumatic Dislocations of the Hand

Carpometacarpal Dislocations.—Dislocation of one or all of the metacarpal joints may occur, and the displacement is more often backward. The dislocation of the first carpometacarpal joint of the thumb is the only one of sufficient frequency to warrant description. This joint may be dislocated backward, forward or outward, but the backward dislocation is by far more common, and may be complete or incomplete. This is caused by direct pressure over the anterior aspect of the metacarpal bones, the muscles of the thenar group acting as a fulcrum. When complete, the thumb is flexed and the posterior extremity of the metacarpal bone is apparent, as a prominence, posteriorly to the trapezium. The extensor tendons can often be palpated over the upper extremity of this dislocated bone. There is, of course, pain, disability, and swelling. Reduction is accomplished with ease by simple traction and direct pressure over the posterior extremity of the metacarpal bone but to maintain reduction may be difficult. After

reduction the thumb must be immobilized in a position of extreme abduction, which can best be accomplished by a lateral malleable splint attached to the external aspect of the forearm and to the posterior surface of the thumb. The splint should be worn for at least three weeks, after which recovery should be uneventful.

Metacarpophalangeal Dislocations.—Dislocation of any one or more of the five metacarpophalangeal articulations may occur, and is quite common from hyperextension of the fingers or thumb. Dorsal dislocation is far more frequent, and dislocation of the first or the metacarpophalangeal joint of the thumb is far more disabling than that of the other joints. The dislocations of the metacarpophalangeal joint of the thumb are posterior, anterior, internal, and external. The mechanism of the injury in posterior dislocation is hyperextension; the anterior capsule becomes ruptured and the proximal extremity of the phalanx passes upon the posterior aspect of the head of the metacarpal bone. Manual reduction of complete dislocation is often impossible and open operation may be required. Closed reduction can at times be accomplished by downward pressure upon the posterior aspect of the dislocated proximal phalanx until there is a feeling of engagement, when flexion will bring the articular surfaces into normal apposition. In many instances this will not accomplish reduction, as the anterior capsule, the sesamoid bones, and the tendons of the long and short flexor muscles of the thumb may be interposed. When this occurs, a lateral incision from 1 to $1\frac{1}{2}$ inches in length is made over the posterior lateral aspect; the interposing material is lifted upward with a blunt elevator and the phalanx may then be reduced with ease. The thumb should be immobilized in extension for two weeks.

Fig. 227.—Dislocation of first metacarpophalangeal joint.

RECURRENT DISLOCATIONS

Recurrent or habitual dislocation of a joint may follow one or more acute traumatic dislocations. Defective anatomical contour, congenital laxity of the joint, and deficiency of muscle power are undoubtedly predisposing causes. Most instances, however, occur in normal in-

dividuals with well developed muscles. Recurrent dislocations are extremely rare in childhood and usually do not occur before adolescence or adult age. The cause of the recurrence is the failure of the tear in the capsule to be repaired by strong fibrous tissue. The rupture of the attachments of muscles and ligaments and their reattachment at abnormal points render the action of such muscles and the integrity of such ligaments deficient. Also, the tearing away of a portion of the articular surface may alter the plane of the joint to such an extent that slight force may cause it to slide out of place. Recurrent dislocations are produced by very slight force; the tendency to displacement may be so great that only a limited range of active motion may be possible without producing complete dislocation. The patient soon learns the possible range and will reflexly protect the joint by not permitting motion beyond this range. Epileptic convulsions are a frequent cause of recurrent dislocations by muscular action; often the dislocation occurs only during attacks of nocturnal epilepsy.

Recurrent Dislocations of the Patella

Recurrent dislocation of the patella is frequent in children and young adults. The dislocation is practically always outward. The cause is an untreated traumatic dislocation, but there are also important predisposing causes, as knock knee, abnormal flattening of the articular surface of the outer condyles of the femur, and the opposing articular surface of the patella, and the insertion of the patellar tendon further outward on the tibia than normal. After the primary injury, the defect in the internal capsule is filled in by scar tissue which stretches, allowing a gradual increase in laxity of the capsule on the inner half of the joint. This obviously relaxes the inner ligaments to the patella and permits the patella to be displaced externally.

Treatment.—Conservative measures, as braces that make pressure over the patella, may be tried with more or less success; apparatus was possibly of more value before the days of aseptic surgery. The only safe and certain procedure in every persistently recurring dislocation of the patella is operation. Reefing or excision of a section of the internal capsule is employed only as an adjunct to other measures, as this procedure alone has been found to fail in a large percentage. Reefing of the capsule is accomplished as in the operation for hernia; a long internal lateral incision is made; the capsule is exposed for several inches and an incision made through the synovial membrane. The joint is carefully inspected for any complicating abnormalities, which if discovered are corrected. The margins of the capsule are overlapped as far as

possible and closed with mattress sutures. An elliptical area of the capsule may be excised, thus rendering the internal capsule tense. When associated with an extreme degree of genu valgum, an osteotomy just above the knee is advisable, especially in young individuals. The great contra-indication to this procedure is that both knees must be corrected at the same time. The following procedure has been successfully employed by the author: A long internal lateral incision is made parallel to the quadriceps, patella, and patellar tendon, exposing the capsule of the knee joint. A long strip of the capsule about 1 to $1\frac{1}{2}$ inches in width is dissected from below upward, leaving the strip attached by a pedicle above. The joint is closed, approximating the cut margins of the capsule, thus tightening and taking up all undue slack that may exist in the internal portion of the capsular ligament, and leaving the pedicled flap free. A scalpel is passed through the patellar tendon from side to side just above the patella. A blunt hemostat is passed from without inward through the tunnel made by the scalpel and the end of the flap is grasped and carried through the tendon to the outer side. The strip is then reflected inward over the anterior surface of the quadriceps tendon and its end stitched to the bone or periosteum over the inner condyle of the femur, thus preventing outward displacement by substituting a new check ligament. If there is undue laxity of the quadriceps tendon, in addition, the insertion of the quadriceps with the tibial tubercle may be chiseled from the tibia and transferred about 1 inch inward and approximated to a previously denuded surface upon the inner aspect of the tibia; or, insertion of the outer fibers of the patellar tendon may be transferred to the mesial aspect, as described by Goldthwait. The wound is then closed in routine manner.

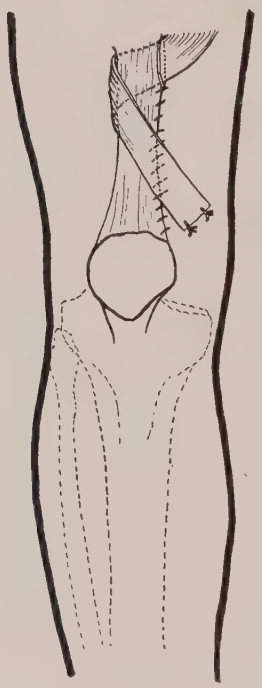


Fig. 228.—Method of repair of habitual dislocation of patella.

The after-treatment consists of immobilization in a plaster cast for six weeks, after which a cage knee splint may be employed for protection, as recurrent dislocations occur more often in young adults in whom protection for a long period of time is required.

Krogius Technic.—Krogius devised an operation based upon the idea that the cause of the dislocation is contraction of the external cap-

sule. An elliptical area several inches in length is excised from the internal capsule. An incision is then made into the external portion of the capsule and the excised section transplanted to the outer side of the quadriceps tendon. The external capsule is thus elongated and the internal capsule closed under tension.

Goldthwait Technic.—The Goldthwait operation consists of an incision over the patellar tendon extending 1 inch below its insertion. The tendon is split longitudinally, and the outer half detached and passed under the inner half to be inserted into the inner aspect of the tibia, if possible, into the insertion of the sartorious tendon.

Gallie Technic.—Gallie has devised a method which has proved very successful and consists of fixation of the patella to the internal condyle of the femur by a ligament of fascia lata or a section from the tendo achillis. Through a medial longitudinal incision, two drill holes are made transversely through the patella and two corresponding holes on the inner condyle of the femur. A free transplant of fascia lata is drawn through the drill holes on the inner condyle of the femur, one end is then threaded through the upper hole in the patella, looped backward upon itself and passed through the lower drill hole of the patella. The ends are then drawn tightly, overlapped and secured by catgut sutures.

Albee Technic.—A semilunar skin incision is made at the outer border of the patella sufficiently long to reach below the tibial tuberosity. The external condyle is exposed and with a broad chisel an incision $1\frac{1}{2}$ to 2 inches long is made into it in the frontal plane about $1\frac{1}{2}$ to 2 inches back of the anterior aspect of the articular surface. By prying the portion of the external condyle in front of the osteotome upward the fragment is elevated so as to project the internal condyle farther forward than its normal position. There is now a gap left in the bone which is filled by an autogenous transplant from the tibia.

Robertson Technic.—Robertson has described a method which consists of detaching the insertion of the semitendinosus tendon and transferring it as near as possible to the patellar tendon. A flap is taken from the patellar tendon from above downward and attached to the end of the semitendinosus tendon. Wilcox has used the gracilis muscle as a ligament in a similar manner.

Recurrent Dislocation of the Shoulder

Recurrent or habitual dislocation of the shoulder is not common, but is more frequent than recurrent dislocation of any other joint. The condition seldom observed in children, more frequently in young

adults, may be continued into old age, but rarely, if ever, begins in elderly patients. The dislocation is usually unilateral but rarely may be bilateral. Recurrent dislocation of the shoulder which is caused by hyperabduction is always anterior and practically always of the subcoracoid type. The greater tuberosity of the humerus is forced against the acromion process which acts as a fulcrum and forces the head against the antero-inferior rim of the glenoid cavity, which again acts as a fulcrum and levers the head out of the socket. The coracohumeral ligament remains intact and is a further aid in the leverage action. At the point where the head passes out of the glenoid cavity the capsule is not supported by muscles when the arm is abducted and is, therefore, the weakest area in the capsule. This is between the insertion of the triceps muscle above and the subscapularis below.

Symptoms.—The symptoms of habitual dislocation of the shoulder may not be apparent except when there is a dislocation. This may occur frequently, almost daily or only a few times a year; trauma may be slight, and rarely, the patient may learn to reduce the displacement by his own muscular volition. In some only a few degrees abduction may cause dislocation, while in others a definite, though slight, trauma with hyperabduction may be required. In those in whom dislocation occurs daily there may be slight or practically no pain; in those in whom definite trauma is required to produce dislocation, the more severe the trauma, the greater is the intensity of the pain. A bursitis, neuritis, or tendon strain may induce constant symptoms. If the surgeon grasps the elbow and suddenly attempts to abduct the arm, a reflex muscular spasm is induced in the pectoral muscles because the patient has learned from experience to abduct the arm cautiously. There may be slight muscular atrophy, the muscles affected being chiefly the supraspinatus and infraspinatus, but also to a lesser degree the coracobrachialis, the triceps, and the deltoid. The atrophy of the spinati is apparent by a slight flattening in contour on the posterior aspect of the shoulder.

Prognosis.—The prognosis with both conservative and surgical measures is unfavorable, which is largely due to inefficient surgical technic. If the procedure selected is efficiently carried out, the percentage of successful results will be higher.

Treatment.—The most important form of treatment is the prophylactic. Recurrent dislocations practically do not occur if the initial traumatic dislocation receives proper care. Gross defect, as rupture of the muscles and avulsion of the tuberosities must be approximated, even if an open operation is required. Conservative treatment is indicated only in those in whom the dislocation has occurred but a

few times. This consists of a shoulder brace to limit abduction which may be made of a leather shoulder cap with strapping to hold the arm to the chest. A band about the chest and arm connected by a strap is also effective. The operative treatment may be classified according to its mechanical objective: (1) Plastic procedures for the purpose of increasing resistance; (2) elongation of certain contracted muscles as an adjunct to capsulorrhaphy; (3) insertion of accessory ligaments by plastic procedures or by free transplants; (4) transplantation of bone for

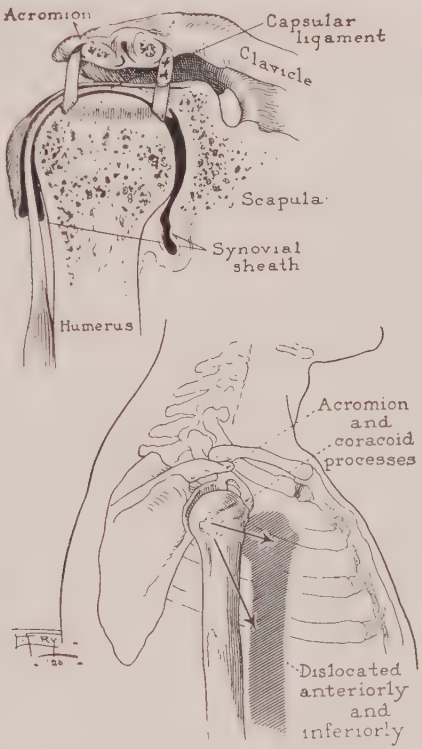


Fig. 229.—Method of repair of habitual dislocation of shoulder.

the purpose of increasing the efficiency of the glenoid cavity; (5) arthrodesis of the joint.

Capsulorrhaphy.—Operations upon the capsule have been viewed with less favor during recent years, and some surgeons have discarded capsulorrhaphy; on the other hand, other surgeons are strong adherents of capsule operations and have reported excellent results. The capsule is exposed, the subscapularis tendon severed and an elliptical area of the capsule excised and the capsule closed with heavy chromic catgut sutures. In addition, the pectoralis, the latissimus dorsi, the teres

major, or other muscles which aid in dislocation by contracture, may be severed at their insertion, and the wound closed.

Clairmont Technic.—An incision about 3 inches in length is made upon the anterior aspect of the shoulder, exposing the anterior border of the deltoid muscle, and a second incision is made on the posterior aspect exposing the posterior border of the muscle. A mass of the deltoid muscle about 1 to 2 inches in width is then separated from the posterior border of the muscle and dissected from below upward. An artery forceps is then passed from before backward through the quadrilateral space; the muscle flap is caught by the forceps and brought through the space and its end attached to the anterior border of the deltoid, forming a sling beneath the head of the humerus.

Henderson Technic.—A curved incision is made with the base upward, extending from just in front of the head of the humerus backward to the posterior aspect of the shoulder. The flap is turned upward, exposing the deltoid muscle and the acromioclavicular joint. A drill, about 10 mm. in diameter is passed through the acromion process or through the acromioclavicular joint. The fibers of the deltoid muscle are then separated anteriorly and posteriorly, the tendinous insertions of the supraspinatus and infraspinatus muscles are separated, and the capsule of the shoulder exposed. The drill is passed through the greater tuberosity of the humerus. A section of the tendon of the peroneus longus consisting of its entire thickness, and about 10 cm. in length is removed from the leg on the same side. The piece of tendon is passed through the drill holes, drawn taut, and the ends sutured with silk. The wound is closed, the arm strapped to the patient's side where it is held securely for ten days.

Carrell Technic.—Carrell uses an ingenuous operation based on the same principles, employing the tendon of the long head of the biceps muscle which may be elongated by attaching to it a strip of fascia lata. He states that the removal of the tendon does not affect the function of the shoulder.

After-treatment.—The postoperative treatment is practically the same after every procedure, and consists of immobilization with the arm at the side for three weeks, when active motion is cautiously instituted. Massage and physiotherapy are also indicated but are not essential. Muscular function must be restored to normal by very careful cultivation.

UNREDUCED DISLOCATIONS

Unreduced dislocations are displacements of long standing which were not reduced during the acute stage. Organization of blood clots

and the resulting fibrosis from irritation of the surrounding tissues produce adhesions which later prevent manual reduction. Dislocations are often overlooked after very serious injuries; this error could and should be avoided if a careful physical examination were made of all patients with severe injuries, and especially those who are unconscious. Unreduced dislocations are seen less frequently than in former years, and at the present time it is almost inconceivable that a gross dislocation could remain unrecognized, if routine roentgenological examinations were made in all persistent joint disabilities.

The joint cartilages may remain intact for an indefinite period and be covered with fibrous tissue and callus. The structure of the bones forming the articulation undergoes marked atrophic changes and the fibrous adhesions become more dense. Osteoporosis or atrophy is early and rapid as the blood supply to the bone is interrupted in every dislocation. The atrophy may be so great that fractures occur if force is employed in attempting a reduction. If the dislocation remains unreduced at the end of three months a new joint gradually forms with a capsule, ligaments, and readjustment of the muscles about the joint by natural functional adaptation. Only a limited range of motion is ever restored, but function is otherwise slightly impaired by the abnormal position. As the new articulation is formed, the atrophic changes in the bone disappear and there is a gradual return to normal structure.

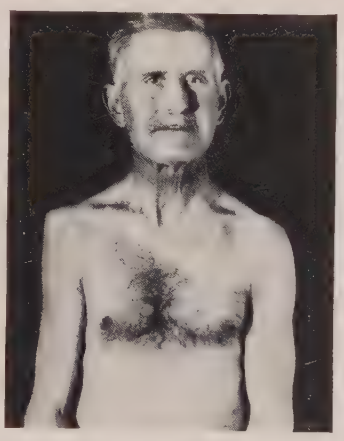


Fig. 230.—Unreduced dislocation of shoulder.

Old unreduced dislocations can be replaced only by open operation. There is no arbitary time when a dislocation may be regarded as unreducible, but, as a rule, after the elapse of three weeks and in some instances less, manual reduction should be undertaken with great care, avoiding excessive force, because of the danger of fracturing one or more of the bones. Wide incisions should be made and the dislocated articular surfaces replaced. The greater the elapse of time after dislocation, the less the chances of securing function. In those in whom years have elapsed since the dislocation or in congenital dislocations in which a new joint has been formed by functional adaptation, improvement in function may usually be secured by operative measures, which must be devised to meet both the requirements of the individual

case and the joint involved. In some instances, reduction is impossible or may require such extensive surgery or such force as to be unsafe. In these a new joint may be made or the joint may be fused at a more advantageous location. In all young adults material improvement in function can usually be secured and the procedure is well justified. In middle age or elderly individuals, the prospects of improvement are not great.

BIBLIOGRAPHY

Albee, F. H.: Orthopedic and Reconstruction Surgery, Philadelphia, W. B. Saunders Co., 1919, p. 627.

Allis, O. H.: The Mechanism and Reduction of Dislocations of the Hip, Trans. Amer. Surg. Assoc., 18:355, 1900.

Bigelow, H. J.: The Mechanism of Dislocation and Fracture of the Hip, with Reduction of the Dislocation by the Flexion Method, Philadelphia, Henry C. Lea, 1869.

Carrell, W. B.: Habitual Dislocation of the Shoulder, Jour. Amer. Med. Assoc., 89:948, 1927.

Clairmont: Ueber neue Operationsmethoden bei habitueller Schulterluxation, Wien. klin. Wchnschr., 30:1507, 1917.

Gallie, W. E., and LeMessurier: Habitual Dislocation of the Patella, Jour. Bone and Joint Surg., 6:575, 1924.

Goldthwait, J. E.: Slipping or Recurrent Dislocation of the Patella with Report of Eleven Cases, Boston Med. and Surg. Jour., 150:169, 1904.

Henderson, M. S.: Tenosuspension for Habitual Dislocation of the Shoulder, Surg., Gynec. and Obst., 43:18, 1926.

Kleinberg, S.: Traumatic Spondylolisthesis, Arch. Surg., 3:102, 1921.

Krogius, A.: Zur Operativen Behandlung der Habituellen Luxation der Kneischeibe, Zentsable. f. Clin., 31:254, 1904.

Robertson, G.: A Method of Treatment of Habitual Dislocation (Congenital) of the Patellae, Surg., Gynec. and Obst., 14:378, 1912.

Stimson, L. A.: An Easy Method of Reducing Dislocations of the Shoulder and Hip, Med. Rec., 57:356, 1900.

Watkins, James: An Operation for the Relief of Acromioclavicular Subluxation, Jour. Bone and Joint Surg., 7:790, 1925.

Ziegler, Ernst: A Text-Book of Special Pathologic Anatomy, New York, The Macmillan Company, 1897.

AFFECTIONS OF THE BONES

CHAPTER X

FRACTURES

The subject of fractures is so complicated that only a brief discussion of those of more frequent occurrence and the general principles of the treatment of each can be considered. In every fracture, in addition to the severed bone, the surgeon must consider the muscular contraction, the ligamentous attachments, the relation of the important nerves and blood vessels, and the injury to the soft parts, as well as the physical condition of the individual patient. A complete physical examination is essential in every severe fracture, for, if both the local and constitutional elements are not considered, it may later become apparent that normal healing processes may be impaired and that either firm union may not occur, or that active use may induce deformity with permanent disability. Due consideration must also be given to conservation of function by measures to prevent restricted movements in the joints from adhesions of the articular surfaces, ligaments, and tendon sheaths.

Some fractures apparently occur more readily at certain ages, for example, fractures in and about the hip joint in the aged, and fractures of the lower extremity of the humerus in childhood. The inherent difference in osseous structure and the epiphyses in childhood influence materially not only the character of the fracture, but also the prognosis and treatment. The bones in the growing child are more pliable and are capable of bending or becoming distorted to a marked degree without actual severance, producing the so-called greenstick fracture. Muscle power is weaker in childhood and, therefore, reduction is accomplished with more ease, and displacement after reduction is not so imminent as in the adult. In children, moderate deformity and displacement of fragments may be corrected by natural growth, which is not possible in the adult. However, there is no intention to imply that in every fracture in child or adult that the attempt should not be made to obtain and maintain the most perfect approximation that is feasible.

Actual healing of fractures is accomplished by the formation of callus or new bone between the fragments; in consequence, the more

accurate the approximation of fragments, the more certain and more rapid the union of the bones. There are three theories of callus formation: (1) Bone is formed by certain specific cells known as osteoblasts; (2) osteogenesis is an inherent function of all cells derived from connective tissue and bone may, therefore, be formed by a process of metaplasia from bone cells, cartilage cells, and connective tissue cells; (3) the local physicochemical reaction causes a precipitation of lime salts from the blood. Callus is formed from the endosteum, the cancellous bone, and the inner layer of the periosteum. Callus in the early stage is flocculent and pliable, but later becomes organized into true bone, but with a greater density than normal bone, except in early childhood when new normal bone is gradually replaced by the growth from the adjacent epiphysis.

The length of time required for the complete organization of callus depends upon age, local condition, and individual peculiarity, as individuals differ in their inherent bone forming elements. The younger the individual, the more rapid the production of callus. Local impairment of circulation naturally delays callus formation. Individuals also differ as to the quality and quantity of callus production. The greater the exposure of the raw surface of the bone in fractures the greater will be the area from which callus or new bone is produced. For a description of the manner of bone production and callus formation, reference can be made to works upon histology and physiology.

Classification of Fractures.—Fractures of the long bones may be classified as to their contour, as follows: (1) Transverse; (2) oblique; (3) spiral; (4) comminuted. A *transverse fracture* is one in which the line of fracture is transverse to the long axis of the bone. This line, however, rarely divides the entire width of the bone at the same level, severing the continuity of the bone smoothly, but is usually somewhat irregular or serrated. An *oblique fracture* is one in which the line of fracture is oblique to the long axis of the bone. The line of fracture, in some instances, is very short or may extend for several inches. In a *spiral fracture* the line of fracture winds about the bone like the thread of a screw and such fractures are usually produced by torsion or twisting forces. *Comminuted fractures* are those in which the bone is splintered or broken into many small particles. The term is also used in reference to segmented or double fractures in which a large fragment is separated from the shaft of the bone. *Fractures of long bones* are also classified according to location, as those of the inner, middle, and outer extremity; or the upper, middle, and lower thirds. *Fractures of irregular bones*, as the innominate bone, are described according to their anatomical direction.

Fractures may be simple or closed, compound or open. *Compound fractures* communicate with the external surface through a lacerated or punctured wound of the soft tissues and skin. They are usually produced by a greater degree of trauma than simple or closed fractures, and are frequently caused by a sharp fragment of bone puncturing the soft structures; the trauma may also be of sufficient force to lacerate the soft tissues. Compound fractures may also be caused by puncture from without, as gunshot wounds. The opening may vary from a small puncture wound to a very large open area in which there may be extensive destruction in continuity of bone and soft tissue. Foreign material, such as dirt, gravel or clothing, may be driven into the tissues with such force that extraction is difficult. The tissues, at times, are devitalized beyond repair and become necrotic. The terms *simple fracture* and *compound fracture* are somewhat confusing, as a simple fracture may be of great severity, seriously complicated, and a difficult surgical problem, although from the term *simple fracture* the impression might prevail that the injury was mild. *Impacted fractures* are those in which a direct force breaks the bone and forces one fragment into the other; such fractures are more common in the spongy bones. *Compression fractures* also occur only in spongy bones, as the vertebrae, when a great force crushes the bone so as to change its dimensions. *Avulsion fractures* are those in which a mass of bone is torn loose with the attachment of a tendon or ligament. The fragment is usually large, for example, the tibial tubercle. *Sprain fractures* are similar to avulsion fractures, but always occur in the vicinity of joints, and the particle of bone is smaller. *Greenstick fractures* are infractions of long bones in which one side of the bone is broken, the other being bent. They are possible only in the developing bones of children. *Congenital fractures* in reality are not true fractures; they are gaps in continuity of bone due to failure of development in the embryo. Congenital fractures should properly be classified as congenital anomalies. *Birth fractures* are those which occur at birth from trauma during delivery and are similar to fractures from other causes occurring at that age.

Epiphyseal separations are caused by rupture of the bone structure along the epiphyseal lines. Epiphyseal separations rarely occur until late childhood, and are treated by the same mechanical principles as fractures, except that perfect approximation is essential. Future growth may be irregular or retarded, with subsequent deformity or shortening in spite of perfect reduction, though this will rarely be appreciable if complete coaptation is secured. In any separation of an epiphysis, the parents must be warned that future growth may possibly be inhibited.

There is no arbitrary time at which a fractured bone becomes united. *Delayed union* occurs when healing is retarded beyond the normal time, although the process of osteogenesis is active. So long as organization of callus into bone is still taking place the union should be regarded as delayed, regardless of the interval of time since the fracture occurred. *Ununited fractures* are those in which the process of osseous fusion has ceased before the callus between the fragments has been organized into bone. *Malunited fractures* occur when proper reduction of the fragments has not been secured and maintained throughout the process of consolidation. The fracture is united but the alignment of the bone is not compatible with good function, because of overlapping, wide separation, or angulation of the fragments.

Symptoms.—The symptoms of fracture are the history of injury, followed by immediate pain, and if separation of the fragments occurs deformity, loss of function, and abnormal mobility. The injury may be caused by either a direct or an indirect force which may be severe or trivial, or by muscular action. Fractures of normal bones may be caused by muscular contraction alone or may occur in pathologic conditions from such minor trauma as turning in bed. An audible cracking sound is frequently heard by the patient or a bystander. Pain in usually present at the time of the injury, although it may not be severe, but persists after the injury whenever the part is moved. A history of pain at the time of the accident is far less important as a symptom than that which can be produced subsequently by movement. Tenderness over the point of fracture on direct pressure is a constant finding. Deformity or alteration in length and contour of the part is due to swelling and change in relation of the fragments. The deformity of displacement may be produced by the violence of the injury, by gravity, or by contracture of the muscles. The loss of function may be immediate and complete following some fractures and may be delayed or partial in others. In the extremities, function is abolished chiefly distal to the point of fracture, the loss being due to pain; true paralysis is not present unless there is an associated injury to the nerves of the extremity, although laymen, and even many physicians, believe that if the patient can move his fingers or toes there is no fracture. Abnormal mobility is the most important symptom and is pathognomonic when demonstrable, but is not always present, as in impacted and greenstick fractures, and may not be demonstrable in fractures in close proximity to joints. Crepitus or crepitation is both audible and palpable. This symptom also is diagnostic, as it is produced by the grating together of the fractured surfaces of the bone fragments, but is only present when the rough bone

ends can be approximated. Other symptoms may be present in certain fractures, such as hemorrhage from the external auditory meatus in fractures of the skull, and hematuria in fractures of the pelvic bones. Ecchymosis of the overlying skin, except in deep-seated fractures, usually develops subsequently to the injury. The integrity of the adjacent nerves and vessels should always be determined at the time of the first examination. In severe fractures, especially of the shaft of the femur, the spine and pelvis, the patient may be in a state of profound shock, which may be best combated by immediate immobilization. When it is necessary to transport a patient from the scene of the accident to a hospital at some distance, the extremity should always be immobilized to prevent further shock. The application of external heat is frequently necessary, and the administration of narcotics, cardiac stimulants, saline or glucose solutions intravenously, and blood transfusions may be required.

Diagnosis.—Every severe injury should be considered and treated as a possible fracture until the roentgenogram proves that none exists. In the extremities a careful comparison of the location of the injury with the opposite or normal part should be made, noting especially the comparative lengths and contours, but the diagnosis should always be confirmed by roentgenographic or fluoroscopical examination. When doubt exists as to the presence of a fracture, a roentgenogram of the opposite side should be made. Two views of the fracture at right angle to each other should be made, an anteroposterior and a lateral view. In those parts where this can not be accomplished, stereoscopic plates are required, so that the third dimension may be observed and the exact relation of the fragments determined. The fluoroscope is not dependable as a diagnostic measure, especially when the injury is in close proximity to the joint, and in children in whom there is a preponderance of cartilage; the fluoroscope is of value in the reduction of long bones. Lead-lined rubber gloves should always be used to protect the surgeon's hands and prevent keratosis which develops after extensive use of the fluoroscope.

Treatment.—Reduction should be accomplished as soon as possible after the occurrence of fracture, but if the necessary facilities are not available, reduction may be postponed for a few days. All the structures surrounding the bone must be considered in the treatment of the fracture. Muscles and ligaments attached to the bone may prevent approximation of the fragments until relaxation is secured. The restoration of the normal approximation of the fragments is the ideal, but the most important factor is to restore normal anatomical alignment and

normal contour which must be maintained until there is complete consolidation. If this fact is constantly borne in mind, the occurrence of deformity with permanent disability would be materially decreased. Reduction may be accomplished by (1) manipulation, (2) gradual reduction by the means of traction, and (3) open operation.

Manipulation.—Manual reduction and retention by proper apparatus until union is solid is the most efficient and practical method when possible. It is efficient, because by this means the best functional results may usually be obtained, and it is practical in many cases, because prolonged hospital care is obviated, the patient is enabled to return to his home with the fracture properly immobilized and thus a serious economic problem is solved. Manual reduction is accomplished by manipulation of the fragments to release all obstruction to approximation and to secure and to end apposition when the surfaces are of such contour as to permit engagement. In certain fractures, the orthopedic table is essential as an aid to manual reduction and the application of apparatus to maintain the position. The manipulations employed are traction, pressure, and angulation of the fragments. Traction overcomes the muscular contracture, reduces the overriding of the fragments, and restores the anatomical alignment of the bone. Pressure on the ends of the fragments in certain directions may approximate the fragments and angulation will frequently allow the ends to be engaged. Transverse fractures are obviously better adapted to manual reduction, but in many oblique or comminuted fractures, sufficient apposition may be secured to retain the position until apparatus can be applied. Apparatus for the purpose of retention will be discussed in its application to the various bones.

Traction.—Gradual reduction by means of traction is necessary in certain fractures. There are four types of traction: (*a*) Fixed traction; (*b*) traction by weights; (*c*) suspension, and (*d*) skeletal traction. Fixed traction is employed by means of adhesive plaster applied to the limb and attached to a fixed point on an apparatus which is made especially to fit the affected part. Traction is made to the desired degree, and is kept constantly in force by frequent adjustments. This method is efficient in retaining reduction or position, but is rarely sufficient actually to engage the fragments. It is also useful as a temporary measure in transportation or until the condition of the patient will permit the application of other measures. Continuous traction by weights and pulleys is also employed through Buck's extension. Countertraction in various directions may be secured by means of overhead and lateral frames and bands about the affected parts. Suspension is rarely em-

ployed alone, but is associated with traction. By hammocks and special splints, suspension is made through attachment to overhead frames. Weights and pulleys are used to regulate the degree of suspension, which is really a form of traction. Suspension combined with traction permits fixation and traction in any position of the limb which may be indicated in order to secure reduction. Skeletal traction is direct and continuous traction upon the bone by means of tongs which grasp the distal fragment, or by means of a spike driven through the bone. Traction is made by weights and pulleys attached to the tongs or to the ends of the spike or nail. Traction is continued until approximation is secured and oftentimes until consolidation occurs. Too prolonged or extensive traction may impair union, and consequently, the apparatus requires frequent inspection and constant surveillance. One advantage of traction is that inspection of the limb is always possible, and physiotherapy to the joints and muscles may be employed which prevents further impairment of function. Traction and suspension may also be employed when the fracture is complicated by lacerated wounds, thus permitting frequent observations and dressings when required.

Open Reduction.—Operative measures should not be considered as a routine method in the treatment of fractures, but are used only in certain fractures which can not be reduced by closed methods. Sutures and various inorganic materials as nails and metal plates are employed to maintain internal fixation of the refractory fragments after open reduction, but should be used with great care and only by a surgeon of experience; scrupulous operative technic is necessary because infection in the bone is a most serious complication. Union is always delayed after incision into a fracture.

After-treatment.—After reduction has been accompanied by the manual method, confirmation of the exact relation of the fragments must be secured. A roentgenogram should be made after application of the splint or cast. If reduction is not satisfactory, a second attempt at reduction must be made, being careful, at all times, not to impose too much injury upon the already traumatized tissues. After a week or ten days, the position of the fragments should be again checked. At the end of two weeks, in certain fractures, and three or four weeks in others, the splints are removed, the entire part inspected as to alignment and roentgenograms made. If angulation or displacement has occurred, realignment or reduction is possible. The splints are reapplied until consolidation is firm. At the time when union of the particular type of fracture is to be expected, the splint is removed and a roentgenogram is again made to determine the position and the amount of union.

A final roentgenogram may occasionally be necessary at a later date after function has been resumed, and in some instances, as in fractures of the hip, roentgenograms must be made for a period of one year or more.

Control roentgenograms at frequent intervals must be made during treatment by traction. However, too frequent exposures may possibly impede callus formation and must be avoided. Callus demonstrable by the roentgenogram, appears earlier in young patients, the production being influenced by the character of the fracture, comminution and stripping of the periosteum, etc. Callus formation varies also in different parts of the skeletal system. The opacity of callus varies in different individuals, although union may be firm; frequently only slight callus may be apparent at the end of several weeks, although clinically, union is firm. The quality of the callus is more important than the quantity in determining the stage of consolidation. Six months to one year may elapse before organization and consolidation are complete. When there is excessive weight or leverage on the fractured bone, and after extensive operations to secure reduction, braces are indicated to prevent angulation. Deformity, especially angulation, may occur after there is apparently solid union; this is not generally appreciated, and much of the disability and deformity resulting from fractures is due to angulation from strain before consolidation is complete.

SIMPLE FRACTURES

Fractures of the Foot

Phalanges.—In fractures of the phalanges, the fragments are not usually displaced, unless the fracture is compound with extensive laceration of the soft tissues. For simple fractures without displacement no splint may be required. When there is pain and swelling a metal splint extending from slightly beyond the tip of the toe to the ball of the foot is sufficient. A splint of the required length and of a width slightly less than that of the toe may be cut from sheet-iron or aluminum; it is bent to conform to the shape of the ball of the foot and the affected toe, covered with adhesive plaster and held in place by bands of adhesive tape placed snugly, but not tightly, about the affected toe and the ball of the foot. A large shoe or slipper may be worn and walking permitted. If the distal phalanx is involved, a hematoma may arise beneath the nail and cause great pain. Relief may be secured by drilling two small holes in the nail to permit the escape of blood, thus relieving pressure. When severe contusions and lacerations of the soft tissues are associated with the fracture, wet dressings are indicated for several

days and weight bearing should not be permitted until healing of the wounds has begun.

Metatarsal Bones.—Fractures of the metatarsal bones are usually caused by crushing injuries. If only one bone is involved, displacement of the fragments is slight, but when two or more are fractured, greater displacement is common, the proximal fragments projecting below the distal. The treatment consists of elevating the proximal fragments by direct pressure under the ball of the foot. Perfect reduction is difficult and often impossible, but the overriding fragments should not be allowed to encroach upon the plantar surface of the foot. The position is maintained by a sole plate of sheet-iron to which is attached a heavy felt pad. The sole plate is bent and applied to the foot with the toes in full plantar flexion, the foot pad being placed beneath the affected area. Strips of adhesive tape and roller bandages retain the splint and

Fig. 231.—Fracture of metatarsal bones. Anteroposterior view.

Fig. 232.—Same as Fig. 231. Lateral view.

pad in position, and the forefoot in extreme plantar flexion. Rarely, when reduction can not be secured manually, an open operation may be required. An incision is made upon the dorsum of the foot parallel to the fractured bones. The distal fragment is replaced using a blunt instrument. A cast may be employed, extending from the toes to the upper third of the leg and maintaining the forefoot in extreme plantar flexion, with a heavy pad or elevation beneath the site of the fracture. Splints are removed at the end of one month, and an insole or arch support applied with an elevation beneath the area of the fracture, and walking permitted. The support is continued for at least three months or until consolidation is complete. Fracture of the base of the fifth metatarsal bone is not uncommon as this portion of the bone is quite

superficial. The fracture is usually comminuted without displacement. The patient complains of much discomfort on walking and a very tender area may be found beneath the base of the fifth metatarsal bone. The treatment consists of a steel insole so padded with felt that there is little pressure over the injured bone; walking is not only permitted, but enforced, as recovery is more rapid than when the limb is placed at rest. Tenderness persists for several weeks, and pads may be required for one or two months.

Tarsal Bones.—In injuries of the foot and ankle, a complete roentgenographic study of the foot and ankle is often necessary. In the foot there are several supernumerary bones, and sesamoid bones, which are frequently mistaken for fractures. The os trigonum is a small supernumerary bone lying posterior to the astragalus, which is often mistaken for a fracture of the posterior extremity of the astragalus. The os tibiale externum, or the accessory scaphoid, is a small sesamoid bone in the tibialis anticus tendon which fuses to the scaphoid, or may remain as a separate bone and is also frequently mistaken for fracture. The anterior calcaneus or secondary os calcis is a small bone lying just anterior to the os calcis which is often diagnosed as a fracture of the os calcis. The os peroneale, a sesamoid bone in the peroneus longus tendon at the anterior outer extremity of the os calcis, the os vesalianum pedis at the base of the fifth metatarsal bone, the intercuneiform between the internal and middle cuneiform bones, and the intermetatarsal between the proximal heads of the first and second metatarsal bones, may also be mistaken for fractures. The inner sesamoid bone of the great toe in the flexor hallucis longus tendon may be fractured or may, at times, arise from two ossification centers without fusion. The appearance of these bones in the roentgenogram may suggest fracture, but errors in diagnosis may be avoided if the occurrence of these abnormal bones is borne in mind, and if roentgenograms of both feet are made for comparison. Dislocations of the bones of the tarsus and the ankle may be associated with the fractures of the foot. Fractures of the scaphoid, cuneiform and cuboid bones are caused commonly by direct violence of a crushing nature, and although displacement of the fragments is unusual, the resulting disability may be severe. A simple splint for immobilization of the foot and ankle may be sufficient until the acute symptoms have subsided, when an arch support is placed in the shoe until there is a return to normal, which requires about two months. In severe fractures of the anterior tarsal bones a longer period of immobilization may be required, and rarely operative measures may be employed to replace grossly displaced fragments.

Os Calcis.—Fractures of the os calcis are of several varieties and present one of the most difficult surgical problems. Rarely slight fractures may occur without displacement, and not infrequently a fracture may occur that is not apparent until several weeks have elapsed, when pain and disability are aggravated. The most common type is the impacted fracture with crushing of the bone and displacement of the posterior portion upward and outward, so that a mass of bone appears beneath the external malleolus. The fracture may be comminuted with fissures extending in all directions. This type is particularly disabling when the fissures extend into the calcaneo-astragaloid articulation. The posterior portion may be avulsed along the attachment of the tendo achillis. The fracture is usually caused by falling on the feet from a

Fig. 233.—Fracture of os calcis with comminution. Anteroposterior view.

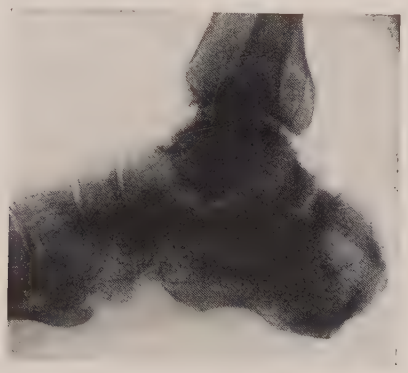


Fig. 234.—Same as Fig. 233. Lateral view.

great height, and frequently both the os calces, as well as other bones are fractured at the same time. The roentgenographic examination of the os calcis has been described in the section on examination of the foot. The lateral view is easily secured; the supero-inferior view is obtained by focusing the rays through the sole of the dorsiflexed foot. The prognosis in fractures of the os calcis is always doubtful, regardless of the method of treatment, and there is often permanent disability. When there is no displacement, and in those injuries not involving the calcaneo-astragaloid joint, the functional results are better, and there is less danger of permanent disability. However, pain may persist indefinitely due to irregularity and subsequent arthritis of the calcaneo-astragaloid joint, causing a persistent traumatic flatfoot. Motion in the subastragalar joint is limited and also all lateral movements of the foot.

Treatment.—Accurate reduction is difficult and often impossible, but satisfactory apposition may, at times, be accomplished by forcibly plantarflexing the foot and flexing the knee to relax the tendo achillis. The heel is grasped by the hand and twisted inward, using a padded wedge-shaped wooden block as a fulcrum. A special instrument, as the Thomas wrench, may also be employed to grasp the foot and afford greater leverage. The outward displacement must be reduced and the inward curve of the normal os calcis restored; the upward displacement of the posterior fragment must also be corrected to restore the proper alignment of the longitudinal arch. The widening of the os calcis is corrected by applying a thick pad of felt below the external malleolus and using a heavy mallet to force the fragments into position. A cast is then applied from the toes to the groin with the knee in flexion and the foot in plantarflexion. If further lateral compression of the os calcis is desired, windows may be cut in the cast on either side of the heel and continuous and gradually increasing pressure made by a clamp with adjustable screws.

Reduction may also be accomplished at times by making an incision just anterior to the insertion of the tendo achillis and passing an urethral sound over the superior border of the os calcis. In this manner, traction may be made directly upon the posterior extremity of the os calcis. A steel pin may be employed in the same manner. Lengthening of the tendo achillis has been used by Bennett as a means of reduction and prevention of the recurrence of the displacement. Wilson has advised fusion of the calcaneo-astragaloid joint immediately after fracture of the os calcis. An incision is made on the lateral aspect of of the foot just below the external malleolus. The peroneal tendons are retracted; the articular cartilage on the os calcis and astragalus is removed, and the denuded osseous surfaces approximated. The after-treatment consists of immobilization in a cast for six to eight weeks, followed by a brace and arch support similar to that used in the after-treatment of the recent fractures.

Astragalus.—Fractures of the astragalus may be caused by crushing forces in the same manner as fractures of the os calcis, or by violent twisting or rotation of the foot. The prognosis is unfavorable, although not so poor as in fracture of the os calcis. In mild fractures excellent results may be obtained; in severe fractures, excision of the astragalus gives excellent results in a higher percentage. Regardless of treatment, excision of the astragalus or arthrodesis of the ankle joint is often indicated for the relief of pain and disability. Fractures of the astragalus may be classified according to the location of the fracture: (1) Frac-

tures of the head and neck; (2) fractures of the body, and (3) fractures of the posterior extremity.

Fractures of the neck of the astragalus are similar to fractures of the neck of the femur, in that nonunion and atrophy of the head may result even after reduction. Fractures of the neck of the astragalus may induce inversion of the foot because of the rotation of the head. This causes a permanent deformity, unless reduced by direct manual pressure upon the head. After reduction the foot is placed in extreme dorsiflexion, as this position maintains the fragments in close apposition. A plaster cast is applied from the toes to just below the knee. In those in whom closed reduction can not be accomplished, an incision is made on the lateral as-

Fig. 235.—Fracture dislocation of ankle. Anteroposterior view.

Fig. 236.—Same as Fig. 235. Lateral view.

pect of the foot, the head of the bone is grasped by forceps and rotated into normal position. Physiotherapy should be instituted at the end of four weeks and weight-bearing with an arch support begun at the end of six or eight weeks, or when union has occurred. Excellent results may be expected in fractures of the neck of the astragalus, when reduction is successful and osseous union occurs. Should atrophic changes occur in the head of the astragalus, there may be persistent pain. The treatment indicated for this condition is arthrodesis or fusion of the astragaloscaphoid and calcaneocuboid joints.

Fractures of the body of the astragalus are usually of the compression or impacted type. In mild compression fractures, the foot may be immobilized in a cast at right angle to the leg, with after-treatment similar to that employed in fractures of the neck. In severe compression fractures with comminution of the body of the astragalus, astragalectomy, as devised by Whitman, for paralytic feet, is indicated. The astragalus is excised, the foot displaced backward on the leg so that the malleoli grasp the anterior extremity of the os calcis, thus forming a new joint between the superior surface of the os calcis and the lower

Fig. 237.—Roentgenogram showing Cotton's fracture. Anteroposterior view.

Fig. 238.—Same as Fig. 237. Lateral view.

extremity of the tibia and fibula, and throwing the balance of weight over the center of the foot.

Fractures of the posterior extremity of the astragalus are caused usually by forced plantarflexion. Pain and swelling are present on the posterior aspect of the ankle joint. The treatment consists of immobilization until acute symptoms subside, after which physiotherapy is instituted. Rarely removal of the loose particles of bone may be advisable. This fracture must not be confused with the accessory bone, the os trigonum. This bone may be united to the astragalus and may be broken loose.

Fractures of the Tibia and Fibula

Fractures of the lower third of the leg consist of combined or separated fractures of the tibia and fibula.

Pott's Fracture.—The most common fracture at the ankle is Pott's

fracture which is caused by a sudden eversion and outward rotation of the foot. The fibula is fractured transversely or obliquely about 3 inches above the ankle joint. The lower fragment is displaced outward and backward, and the body of the astragalus and the foot are dislocated outward and backward. The internal malleolus of the tibia may be broken loose and displaced downward and forward, or the internal malleolus remains intact, the internal lateral ligament being torn. There may also be a tear of the tibiofibular ligament with separation of the two bones. This gives a grotesque appearance to the foot which is displaced outward and backward, making the lower extremity

Fig. 239.—Pott's fracture of ankle. Anteroposterior view. Note fracture of fibula, internal malleolus of tibia and outward displacement of astragalus on tibia.

Fig. 240.—Same as Fig. 239. Lateral view.

of the tibia very prominent. Unless reduction is perfect, permanent disability with pain and lack of endurance may be expected. The heel and forefoot are grasped by the surgeon, and the dislocation of the ankle reduced by a forward push upon the heel; the foot is then sharply inverted at the subastragalar joint, but not at the midtarsal joints. Roentgenograms, both anteroposterior and lateral views, are made which should show the restoration of the normal relations; the astragalus must be reduced to its normal position between the malleoli, the line of the ankle joint must be transverse to the long axis of the leg, and the inner aspect of the astragalus must lie in close approximation to the

outer surface of the inner malleolus. The position of the foot at right angle to the leg and strongly inverted must be maintained. There are numerous methods of retention, but probably the simplest is a cast extending from the toes to just below the knee, or if the patient is very obese the cast should extend above the knee which is flexed. Frequent control roentgenograms are made to confirm the position of the fragments; the slightest displacement demands remanipulation. In those in whom the internal lateral ligament is ruptured, retention is more difficult than when the internal malleolus is broken; also great care must also be taken when the tibiofibular ligament is torn to prevent widening of the mortise of the ankle joint. Physiotherapy may be instituted at

Fig. 241.—Pott's fracture after reduction. Anteroposterior view. Note restoration of normal weight-bearing line.

Fig. 242.—Same as Fig. 241. Lateral view.

the end of three or four weeks. Weight is borne at the end of six weeks by the aid of an arch support and an ankle brace, as valgus deformities may arise if callus is not sufficiently solid and strong to prevent deviation. The brace is worn for three months and the arch support for six months, depending, of course, upon the age and weight of the patient and the type of the fracture.

Cotton's Fracture.—Fracture of the posterior tip of the tibia with a portion of the shaft occurs independently or at times in association with Pott's fracture; this variation is termed Cotton's fracture. Greater care must be taken in reducing the posterior displacement which will usually reduce the fracture. In fractures of the anterior margin of the

tibia, the loose fragment may be displaced downward and engaged between the neck of the astragalus and the tibia, thus blocking dorsal flexion. Manual reduction is usually possible. In fractures about the ankle perfect reduction is required, and if these loose terminal fragments can not be reduced, an open operation is required.

The Shafts.—Most fractures of the lower and middle thirds of the leg are oblique or spiral, but many present sufficient transverse surfaces by which engagement may be secured. When both bones are involved

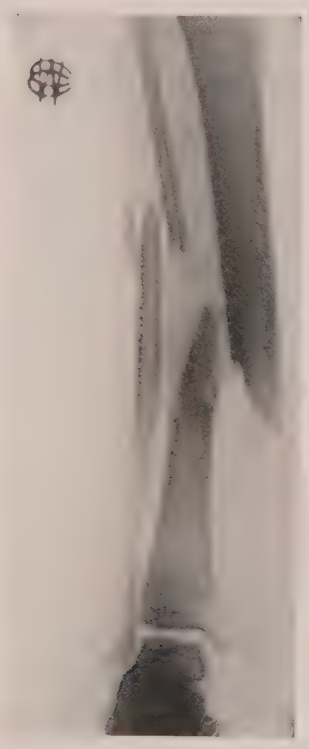


Fig. 243.—Fracture of shafts of tibia and fibula. Anteroposterior view.

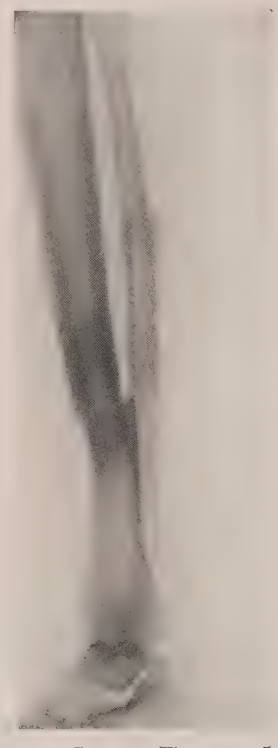


Fig. 244.—Same as Fig. 243. Lateral view.

in fractures of the lower third of the leg, the two should be considered as one bone, but reduction of the tibia is the more important. If satisfactory reduction of the tibia is accomplished, overriding of the fibula is permissible. When either bone alone is fractured, there is usually slight, if any displacement of fragments; hence, the treatment is largely a matter of retention by efficient splints. Fractures of middle third of the tibia and fibula are usually oblique or spiral and require no unusual effort to secure reduction as do those of the lower third. Fractures at

the junction of the lower and middle third of the tibia are the most common type, are frequently compound, and often result in delayed union or nonunion on account of interference with the nutrient artery. Often, in spiral fractures with rotary displacement, especially in the lower third, reduction can be accomplished only by open incision; after reduction retention is maintained by sutures of chromic catgut passed through drill holes in the fragments. In the majority, reduction may be accomplished manually by angulation, lateral pressure, and traction.

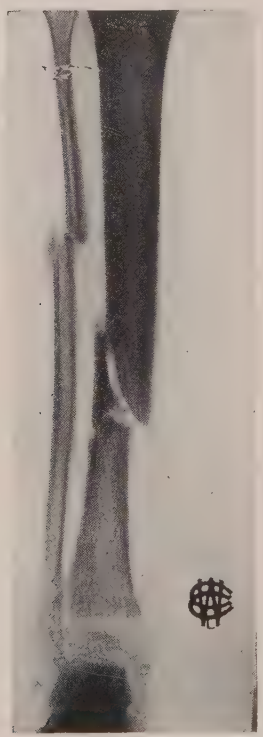


Fig. 245.—Fracture of shaft of tibia and fibula after reduction. Anteroposterior view.

Fig. 246.—Same as Fig. 245. Lateral view.

After reduction, retention is secured by a plaster cast with the foot at right angle to the leg and the knee flexed. The cast should extend from the toes to the groin. In those fractures in which apposition is difficult to maintain, skeletal traction is employed by some surgeons, though such procedures are rarely necessary. This is accomplished by inserting a steel pin about $\frac{1}{4}$ inch in diameter just anterior to the tendo achillis and in close proximity to the upper surface of the os calcis. This pin is passed from side to side, projecting about 2 inches on either side. To

both ends of the pin ropes are attached which are fastened to a weight and pulley. The limb may be supported by a Thomas knee splint or some type of sling. In this manner direct traction is made until reduction is accomplished.

Fractures of the upper extremity of the tibia may involve one or both condyles. Slight or gross displacement may occur with irregularity in contour of the knee joint. There may be comminution with loss in transverse continuity of the joint. The external condyle is more frequently displaced than the internal, and often reduction is impossible by any external means. Open reduction is often required to restore the joint surface to normal. An incision is made over the external condyle extending into the joint, the loose fragment located, and a nail is driven through the fragment which may then be rotated into position, using the nail as a lever. After the condyle is in position, the nail is driven into the shaft of the bone, and a second nail is usually required to insure maintenance of the reduction. It may be impossible to replace and secure comminuted loose fragments, but if the articular surface is not uneven a good functional result may be expected. A posterior splint or cast is applied, extending from the foot to the buttocks or groin. At the end of three weeks, passive and active motion is instituted by overhead slings and pulleys, and also physiotherapy. Joint function is usually restored. However, whenever there is an extensive fracture within a joint the possibility of persistent traumatic arthritis is to be considered. Fractures of the spine of the tibia with or without displacement of the anterior crucial ligament are usually treated successfully by immobilization. Rarely the removal of a loose fragment may be required. In either instance a satisfactory result is to be expected.

Epiphyseal Separations.—Either the proximal or distal epiphyses of the tibia and fibula may be displaced; separation of the lower epiphysis is more common. Reduction is accomplished in the same manner as fractures in similar regions of the bones.

Fractures of the Patella

Fractures of the patella may be caused by direct violence or muscle pull. The lower third of the bone is more frequently fractured in a transverse direction. The lower fragment is usually comminuted and rarely there may be comminution of the entire patella. In all complete transverse fractures there is separation of the fragments by contraction of the quadriceps tendon with a definite depression which is palpable between the fragments. The knee joint becomes distended rapidly from hemorrhage and there is excessive swelling of the soft tissues.

When there is no separation of the fragments, simple immobilization of the leg by a posterior splint is sufficient; when the fragments are separated, the treatment is always surgical. Operation is usually deferred for eight or nine days, until the acute swelling subsides and the tissues have reacted locally to prevent infection. In planning the operation the incision should be made through healthy skin, avoiding excessively traumatized areas. A transverse incision is made, curving slightly above the line of fracture; each end terminates on the lateral aspect of the patella, so that the raw surface and the lateral aspects of the upper fragment and the lacerated tissue adjacent thereto are exposed. Drill

Fig. 247.—Fracture of the patella with wide separation of fragments.

Fig. 248.—Same as Fig. 247. After open reduction and suture.

holes extending into the joint cavity are made in both fragments. Heavy kangaroo-tendon sutures are passed through the holes, the fragments closely approximated, replacing as far as possible each comminuted fragment and the sutures tied. If the bone is severely comminuted, a purse string suture about the entire patella may be necessary. The lacerated tendon on each side is repaired with a continuous suture of No. 2 chromic catgut. Silver wire has been advised as suture material, and has the advantage that earlier active and passive motion may be instituted. Foreign body reaction and infection, however, are more probable. Absorbable sutures have been found sufficiently resistant, if followed by immobilization in extension for three or four weeks. Active and passive motion is gradually instituted and cautiously in-

creased until full function is secured. Fibrous union, which is not incompatible with good function, is said to be frequent, but with well directed after-care, osseous fusion can be secured. The results in simple closed fractures of the patella are excellent.

Fractures of the Femur

Fractures of the femur may be divided into: (1) Fractures of the lower extremity and condyles; (2) fractures of the shaft, and (3) fractures of the upper extremity involving the trochanters, neck, and head.

The Lower Extremity.—The more common types of fracture involving the lower extremity of the bone are: (*a*) Transverse, oblique, or comminuted fractures just above the condyles; (*b*) T-shaped fractures which consist of a transverse fracture above the condyles and a longitudinal fissure between the condyles; (*c*) fractures of the internal and external condyles separately, with downward or lateral displacement of the detached fragment; (*d*) compression fractures of the articular surfaces, and (*e*) separation of the lower femoral epiphysis.

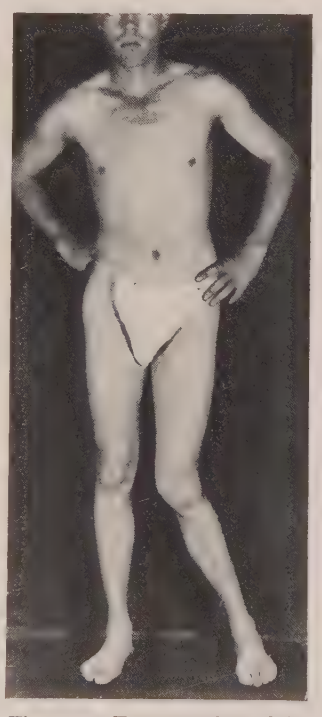


Fig. 249.—Fracture of condyles of femur with genu valgum.

Supracondylar Fractures.—In fractures above the condyles or in separation of the lower femoral epiphysis, there is a backward displacement of the lower fragment due to contraction of the gastrocnemius muscle, the two heads of which are inserted into the posterior aspect of each condyle. This displacement may be so great that the lower fragment is rotated as much as 45 degrees and the uncovered osseous surface faces directly backward. Such backward displacement may seriously impair the circulation by direct pressure or laceration of the artery by loose spicules of bone. The pressure may completely obliterate the artery, and, unless relief is immediately obtained, gangrene may ensue. Reduction is accomplished by flexing the knee to 90 degrees and making traction upon the leg. Angulation of the fragments may be secured by pressure of the closed fist in the popliteal space, while the knee is flexed. Also extreme flexion with downward pressure upon the

flexed leg and backward pressure over the lower end of the shaft may completely or satisfactorily approximate the fragments. After reduction, a cast is applied from the toes to just above the crest of the ilium, with the knee flexed 150 degrees. A Thomas splint, or similar apparatus, with the knee flexed, may also be employed, the principle being support upon a double inclined plane. If reduction can not be obtained manually, skeletal traction with ice-tongs or a steel nail through the condyles may be used; reduction is thus gradually accomplished. Open reduction may at times be necessary. A lateral incision is made and the fragments levered into apposition by a blunt instrument. Sufficient mechanical

Fig. 250.—T-shaped fracture of condyles of femur.

Fig. 251.—Same as Fig. 250. After reduction.

impingement may be secured usually without internal fixation, but some type of bone-peg or silver wire may be required. The author prefers a small autogenous graft from the tibia for this purpose. In those with impaired circulation in whom reduction, with restoration of the tibial pulse, can not be secured at once, open reduction must be performed immediately.

T-shaped Fractures.—In T-shaped fractures the same backward displacement of the lower fragment is present, with the addition of a separation of the condyles laterally. The condyles must be reduced by rotation and compression of the inner fragment outwardly and of the outer fragment inwardly. The reduction may be accomplished by means of the

hands, a steel clamp, or a nail driven into each condyle to be used as lever. As the condyles are approximated, the normal contour of the articular surfaces must be restored. The transverse fracture above the condyles must then be reduced in the manner previously described, and the subsequent treatment is the same as that for fractures of the femur above the condyles. When the contour of the joint can not be restored manually, open reduction with internal fixation is required, using for this purpose a steel nail, a beef-bone screw, or preferably an autogenous bone-peg from the opposite tibia. After reduction of the condyles the horizontal portion of the fracture may be easily approximated.

Condylar Fractures.—In a fracture of one condyle, reduction may be accomplished usually by manual pressure, but if the joint contour can

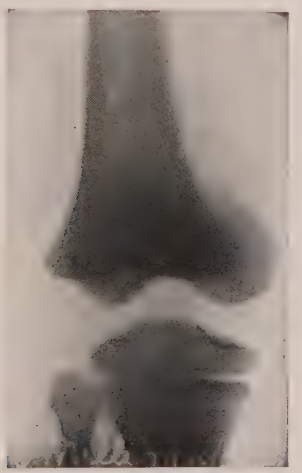


Fig. 252.—Epiphyseal separation of lower femoral epiphysis. Anteroposterior view.

Fig. 253.—Same as Fig. 252. Lateral view.

not be thus maintained, the fragment should be held in position by a nail, as in fractures of the tibial tubercle.

Compression fractures of the condyles are rare and should be treated conservatively. If permanent disability with laxity and persistent valgus or varus deformity, an osteotomy may be required to restore alignment.

Epiphyseal Separations.—The lower femoral epiphysis may be displaced backward or forward after severe trauma and may impinge upon the popliteal artery with serious circulatory disturbances; consequently, close observation of the pulse in the leg is advisable, and if weak or obliterated, reduction must be made at once; or, if this can not be accomplished, blind shifting of the fragments may relieve pressure on the ar-

tery. Separation of the lower femoral epiphysis may also induce genu valgum or other irregularities. External inspection may show apparently normal anatomical alignment, while internally there is gross displacement, which obviously impairs the function of the knee joint with complete arrest of growth at this point. If reduction can not be performed under the fluoroscope, a lateral incision should be made down to the point of fracture and the fragments replaced. Before closing the wound, a roentgenogram should be made in both dimensions to confirm reduction, as it is impossible to determine accurately the relation of fragments by inspection through the incision. A plaster cast extending from the

Fig. 254.—Spiral fracture of shaft of femur. Anteroposterior view.

Fig. 255.—Same as Fig. 254. Lateral view.

toes to the crest of the ilium is the most efficient method of retention, for lateral as well as anteroposterior displacement must be prevented until union is complete.

The Shaft.—In fractures of the shaft of the femur, the lower fragment is displaced backward, and the upper fragment forward and outward. Muscular contraction draws the lower fragment upward and causes overlapping of the fragments; the contraction of the gastrocnemius muscle pulls the lower fragment backward and the contraction of the quadriceps tendon also increases the backward angulation. The lower the point of fracture in the shaft, the greater is the interference

to reduction by contraction of the gastrocnemius muscle; the higher the fracture in the shaft, the greater is the displacement of the upper fragment forward and outward by the contraction of the psoas muscle attached to the lesser trochanter. The fibers of the vasti muscles may also obstruct reduction by their interposition between the fragments.

The transportation of patients with fractures of the femur may be accomplished with greater comfort, less danger of injuring the soft structures by projecting fragments, and less profound traumatic shock, if the limb is immobilized. This is best accomplished by a Thomas splint of suitable size to conform to the extremity, and fixed traction. When a Thomas splint is not available, the femur may be immobilized by

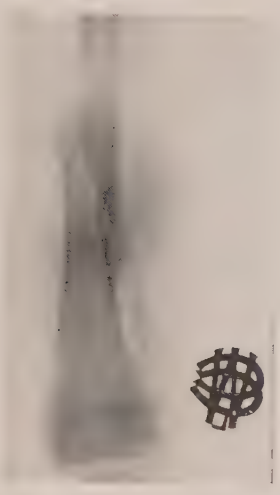


Fig. 256.—Spiral fracture of femur after reduction. Anteroposterior view.

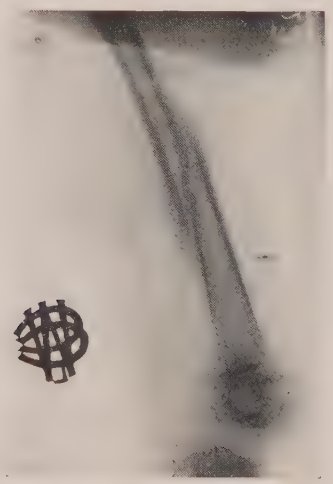


Fig. 257.—Same as Fig. 256. Lateral view.

wooden splints, one extending from the sole of the foot to just below the axilla, and the other from the sole to the perineum. These splints are well padded with cotton, and manual traction by an assistant is made at the ankle while they are being applied. Adhesive strips are fastened about the extremity, pelvis, and chest, and a muslin bandage further compresses the limb and body.

Fractures of the lower third of the shaft of the femur near the condyles require measures similar to those employed in fractures of the lower extremity. The method of reduction for fractures of the middle and upper thirds of the shaft differs from that required in the lower third. Manual reduction of transverse fractures of the shaft is accomplished by bringing the lower fragment into approximation with the

upper fragment. The hip and knee are flexed and the fragments angulated anteriorly until approximation can be secured. A distinct resistance of the lower against the upper fragment is quite evident when the ends are engaged. The angulation is then corrected and the leg placed in anatomical alignment, the hip being flexed 150 to 130 degrees and the knee about 150 degrees. The relation of the fragments is confirmed by the fluoroscope; if end-to-end engagement with one fourth approximation is apparent and the reduction is stable, satisfactory results may be expected. In many instances, perfect approximation with end-to-end engagement may be secured. A plaster cast is applied, extending from the nipple line to the toes on the affected side and to the knee on the unaffected side. An orthopedic table is almost essential for

Fig. 258.—Plaster-of-paris double spica cast used in treatment of fractured femur, showing flexed position of hip and knee.

retaining the position during the application of the cast. After the cast is applied, anteroposterior and lateral roentgenograms are made to confirm the position observed with the fluoroscope. At the end of two to four weeks the cast is bivalved, the contour of the limb examined, the length determined by measurement, and roentgenograms made. At this time, if the position is not satisfactory, reduction can again be made.

The cast is removed at the end of four to six weeks in children and after eight weeks in adults. A Thomas splint with a joint at the knee may be applied to permit passive and active movements by the aid of the overhead sling; physiotherapy should be routinely employed. In adults, a caliper brace is applied before walking is permitted; the necessity for the brace is greater as age advances, as union in the shaft of the femur must be exceedingly strong to permit weight without bowing. Angulation is not an uncommon complication, even after union is apparently solid clinically, and the roentgenogram demonstrates an

abundant callus production. The brace is worn until there is complete consolidation which, as a rule, requires from two to three months.

Oblique and comminuted fractures may be treated in the same manner or with the hip and knee extended. Forcible traction is required for reduction and the plaster cast is applied while the traction is continued. If there is an overlap of the fragments when the cast is changed, further traction under anesthesia will usually approximate them and restore the normal length. The results of manual reduction in children are practically perfect. In adults, displacement of fragments occasionally occurs and a second reduction may be necessary. In adults, restricted movement more often produces stiffness of the knee, but, as the limitation of motion is so seldom permanent, it is not to be considered a serious complication.

The Thomas splint alone is effective only when there is no tendency to displacement of fragments, as in greenstick fractures, or as a convalescent measure after union is practically solid. It is unsatisfactory as a means of reduction or retention after manual reduction. The traction method of treatment requires constant surveillance by those especially trained in its application, but when efficiently carried out, the results are excellent. Traction by Buck's extension may be applied with the limb suspended in a Thomas splint. Traction and suspension are made by a system of pulleys attached to an overhead frame, as the Balkan frame, and reduction is thus gradually accomplished. Skeletal traction may also be applied by tongs which grasp the condyles of the femur or by steel spikes driven through the shaft of the femur just above the condyles. Care must be taken to draw the skin upward when the small incisions are made through which the traction instrument is inserted, so that there will be no tension on the skin wound, and also care should be taken that the apparatus is concentrically applied. Frequent confirmation of the position of the fragments is made by the roentgen ray. Actual separation of the fragments with elongation of the soft structures must be avoided. Ten to thirty pounds of weight are required for one to two weeks; as soon as reduction is secured, the traction is reduced to the amount necessary for the detention of the fragments in apposition. During the treatment physiotherapy and movements may be carried out to prevent stiffness of the knee joint.

Open reduction of fractures of the shaft of the femur, with internal fixation by steel plates, may give excellent results in the hands of an experienced surgeon, but is not to be advised routinely.

The Upper Extremity.—Fractures of the upper extremity of the femur occur more frequently in those past middle age, although no age

is exempt. They may be classified as: (*a*) Subtrochanteric; (*b*) trochanteric or extracapsular; (*c*) central or intracapsular; and (*d*) capital.

Subtrochanteric and Trochanteric Fractures.—Subtrochanteric fracture is a fracture just below the greater trochanter of the femur; trochanteric fracture is one in which the line of fracture follows roughly the intertrochanteric line. The lesser trochanter is frequently detached and separated from the femur by the contracture of the psoas muscle. In both the subtrochanteric and trochanteric fractures, the line of fracture lies outside the capsule of the hip joint. Subtrochanteric and trochanteric fractures follow severe trauma, as violent torsion and blows sustained in railroad or automobile wrecks. On examination the limb

Fig. 259.—Roentgenogram showing intertrochanteric fracture of femur.

Fig. 260.—Same as Fig. 259. After reduction.

is rotated outward, the patient is unable to move it voluntarily, and there is a slight anterior bulging about the hip. The differential diagnosis between trochanteric and central or true fractures of the neck of the femur is difficult and often impossible without the aid of the roentgenogram, but as the prognosis and after-treatment vary materially, an accurate diagnosis is essential. The pain is more intense in trochanteric fractures, and the shortening of the limb is greater. The roentgenogram will always demonstrate the exact nature and location of the fracture.

Fractures of the hip and fractures about the trochanters of the femur are serious surgical problems and require expert treatment, and special equipment, and consequently, should not be treated except in those hospitals where such facilities are available. In subtrochanteric

and intertrochanteric fractures the patient is placed upon a fracture table, the limb is fully extended, moderately abducted and rotated slightly inward, while traction is made. A roentgenogram is made, and if the position is satisfactory, a cast is applied, extending, as in fractures of the shaft, from the nipple line to the toes on the affected side and to the knee on the normal side; a wooden bar is incorporated between the limbs to prevent strain upon the cast. Union always occurs by the end of six or eight weeks, at which time the cast is removed and physiotherapy instituted. Walking is permitted two to four weeks after the removal of the cast, or as soon as the individual is physically able. Crutches are used for one or two months when they may be gradually discarded, although subsequent injuries must be avoided, especially in the aged. Excellent results are also reported by the suspension and traction method with the Hodgkin splint. In subtrochanteric fractures, open operation with internal fixation may be required. However, in the aged, such measures are not advisable, as good functional results are always secured, even though some displacement persists. Any form of treatment which will secure anatomical alignment of the limb will give a good result, but there will be less impairment of function by manual reduction and the application of a cast on an orthopedic table than by any other method routinely employed.

Intracapsular Fractures.—Central or intracapsular fractures are fractures of the neck of the femur, the site of the fracture being intracapsular or within the capsule of the hip joint. Central fractures of the femoral neck, especially in the aged, may follow very slight injuries, or possibly may be pathologic as a result of bone atrophy incident to old age. The fracture may rarely be impacted and remain unrecognized, or after a few days the impaction may become broken up with the appearance of the typical symptoms.

Intracapsular fractures of the neck of the femur present a more serious surgical problem than fractures elsewhere in the skeletal system, as osseous union is notoriously defective at this point. This is possibly due, first, to failure in reduction and failure of retention for a sufficient length of time to secure union, which is particularly true in the aged in whom there are atrophic changes in the osseous tissues; second, weight in this region is borne on an oblique axis; third, the main circulation to the head is derived from the trochanter, and is severed when there is a fracture through the neck. Regardless of the causes, it is a well known clinical fact that central fractures of the neck of the femur fail to unite more frequently than those elsewhere in the body. This fact has been so apparent that up until recent years, the general

opinion prevailed that intracapsular fractures of the neck of the femur did not unite by osseous union.

Treatment.—Manual reduction by the abduction method, as described by Whitman, is the most efficient measure. The patient is placed upon an orthopedic table, or on a similar apparatus employed for the application of a spica cast. The hip is manipulated to disengage possible impaction of the fragments, carried to the limit of abduction, slightly hyperextended, and the extremity rotated moderately inward. The trochanter should also be lifted or pushed anteriorly. This position approximates the fragments by rotating them into apposition after which they are held by the tense Y-ligament, the abductor muscles being relaxed. Artificial impaction, as recommended by Cotton, may be performed by striking four or five forcible blows over the trochanter

Fig. 261.—Central fracture of neck of femur.

Fig. 262.—Same as Fig. 261. After reduction.

with a heavy mallet, the skin being protected by a heavy pad of felt. A roentgenogram is made to determine the position of the fragments and a double spica cast applied. Stereoscopic roentgenograms should be made through the cast to determine the exact relation of the fragments, for the trochanter may be displaced anteriorly or posteriorly to the head.

The after-treatment is very important, especially in the aged, and meticulous care in nursing must be observed, otherwise death may ensue from hypostatic pneumonia or uremia. During the first twenty-four hours the position of the patient must be changed every two hours by elevating the head of the bed. When the cast is sufficiently dry the patient may be turned to the side, or even to the prone position. A fracture bed, or an overhead bar on an ordinary bed will greatly fa-

cilitate changes in position. In the debilitated, the cast may extend only onto the affected limb, and the patient may then be gotten out of bed to stand or sit upon a high stool at intervals during the day. All urine must be measured and the total quantity recorded for each twenty-four hours; at least 30 ounces should be passed within twenty-four hours. Routine urinary examinations must be made every second day. Any appreciable decrease in amount should warrant a quantitative estimation of the blood urea and nonprotein nitrogen. Liquids should be given freely, from 1 to 2 quarts of water orally between meals, or saline or glucose solutions by proctoclysis, hypodermoclysis, or intravenous injection if the patient can not retain the desired amount by mouth.

At the end of eight weeks the cast is removed and a roentgenogram made, which will show the relation of the fragments, but will not determine the degree of union. An abduction hip brace of the Bradford type, with pelvic and chest bands attached, is placed on the patient who may be lifted to a rolling chair. At the end of the third month the joint at the hip is unlocked and the patient permitted to sit up in bed or in a chair. A third roentgenogram is made, which still determines only the position and at the end of the fourth month after the fracture, another roentgenogram is made and if the position of the fragments has not changed, walking with crutches and the brace is permitted. At the end of five months the brace may be reduced to a Thomas caliper brace, and walking continued with crutches. At the end of six months, crutches are discarded, and in favorable cases, at the end of eight months the brace is discarded. The roentgenogram, at the end of eight months, if the position of the fragments has not changed, should show solid union. At times union may be apparent earlier; however, many fractures which were apparently solidly united, have separated and become ununited fractures, even after six months. Therefore, protection and observation must be afforded for a long period of time. Other methods of treatment by suspension and mild traction with abduction are employed, and successful results have been reported; however, all measures must maintain the abducted position if successful union is to be expected.

Capital Fractures.—Fracture of the head of the femur rarely occurs, except as a complication of dislocation of the hip joint. The cause is usually a direct thrusting force and the fragment is often impacted. The diagnosis is made by the roentgenogram. The treatment consists of immobilization with traction, as there is frequently a tendency toward displacement of the detached fragment when the fracture is unimpacted. Repair is usually rapid and complete, if the fragments are retained in apposition, as the blood supply to the head is not disturbed.

Epiphyseal Separations.—Separation of the upper femoral epiphysis is rarely observed until late childhood or about adolescence. In early and middle childhood, the same force that produces epiphyseal separation in older children will cause fracture of the neck of the femur or, more often, the upper third of the shaft. The mechanical principles of reduction of separation of the upper femoral epiphysis are the same as for central or intracapsular fractures of the neck of the femur in adults, and consist in placing and retaining the hip in full abduction with moder-

Fig. 263.—Separation of upper femoral epiphysis.

Fig. 264.—Same as Fig. 263. After reduction.

ate internal rotation and hyperextension by a plaster cast which extends from the toes to the nipple line on the affected side and to the knee on the normal limb. Flat view roentgenograms are not sufficient to determine the relation of the head to the neck, and stereoscopic roentgenograms should be made in every case. If replacement is not accurate, reduction by open operation is required. Malunion after separation of the upper femoral epiphysis is discussed as a type of coxa vara.

Fractures of the Pelvis

Fractures of the pelvis occur frequently from falls from high places, or from severe injuries, as automobile accidents, by lateral and anteroposterior compressure of the pelvis. They are frequently multiple, involving several points in the pelvic rim. Fractures of the anterior portion of the osseous circle, involving the pubic bones and ischiopubic rami are more common, but fractures of the ilia are not rare. There may also be a fracture of the rim of the acetabulum or the head of the

femur may be driven through the pelvis, fracturing the inner wall of the acetabulum. Fracture of the superior wall of the acetabulum is not infrequently associated with posterior dislocation of the hip. There may or may not be displacement of the fragments. When there is an inward displacement, the symmetrical contour of the true pelvis is altered, which, in women, may produce a serious obstetrical problem. In fractures through the ilium, pubis, and ischium there may be upward displacement of one half of the pelvis, inducing a permanent tilting, with incident compensatory curvature of the lumbar spine and actual shortening of the limb. Rarely the lumbosacral plexus may be injured

Fig. 265.—Fracture of ascending and descending rami of left pubic bone. The urethra was ruptured.

at the point where the nerve trunks leave the spine, causing paralysis of the leg. The most serious complication is injury to the hollow viscera; the urinary bladder and urethra are frequently ruptured or lacerated, the rectum less frequently.

In all fractures of the pelvis, a careful examination is necessary. A rectal examination should be made and in women a vaginal examination may be of value. Tenderness and bony irregularity may thus be demonstrated and rarely crepitation. Measurements from the umbilicus to each internal malleoli will indicate distortion or upward displace-

ment of one half of the pelvis. When there is retention of urine a catheter should be inserted; if the catheter can not be passed easily, if the flow of urine is not free, or if the urine returns highly colored with blood, rupture of the bladder or urethra is apparent. Urethral injury is often apparent by external tears and extravasation of urine, or may be determined upon catherization or the introduction of a sound. When the fracture is complicated by injury to the urinary tract, a competent genito-urinary surgeon should be called in consultation.

Treatment.—In simple localized fractures of the ischium or pubic bones, without displacement, rest in bed, or upon a Bradford frame, for a few weeks may be sufficient. The most effective method of immobilizing a fractured pelvis is a plaster-of-paris cast. Traction is made upon both limbs to realign the displaced parts; lateral pressure, and internal manipulations, with the finger in the rectum or vagina, may also be necessary. Encroachment of displaced fragments into the true pelvis must be prevented, especially in women. Lateral pressure upon the iliac bones, when fractured, is dangerous, as it may cause an inward displacement of the fragments. A double plaster spica cast is applied from the knees to the nipple line, being careful to mold the bandages snugly about the pelvis. When the fractures are severe with much displacement, in which case extensive traction is required for reduction, the cast may be extended to the toes to include the entire lower extremity. At the end of six weeks the cast is removed and a low spinal brace with a sacro-iliac belt is applied; the brace is worn for about six months. This is essential, as continuous pain in the lumbosacral and sacro-iliac joints is often present. Fractures of the pelvis may also be treated by suspension in a swathe or sling, as described by Conwell. The patient reclines upon a Bradford frame, the sling surrounds the pelvis and is attached to an overhead frame by a system of pulleys and ropes. A spreader should be placed in the sling to prevent compression of the pelvis. Traction upon both lower extremities may be indicated when there is displacement of the fragments in a sagittal plane. Strapping with adhesive tape may also be of value in fractures of the pelvis.

In separation of the symphysis or in transverse fractures through the pubic bones adjacent to the symphysis, there will be a wide separation, possibly several inches. This may be overcome by tight lateral compression with adhesive tape extending about the entire pelvis. Rarely operative incision with suture of the fragments with wire or heavy silk may be required. Fractures of the superior wall of the acetabulum, with dorsal dislocation of the hip, may be reduced manu-

ally or open incision may be required. Linear fractures into the acetabulum require only immobilization followed by physiotherapy. Rarely permanent disability may occur from an incident traumatic arthritis, regardless of the treatment.

In fractures of the floor of the acetabulum, in which the head of the femur is driven vertically through the acetabulum, the treatment consists of reduction under deep anesthesia, as described in the section on central dislocations of the hip. Since the head may be caught by bony prominences, longitudinal and lateral traction, as well as pressure from within, may be required. Gentle manipulation may disengage the head more satisfactorily than extreme force. After reduction, Buck's extension is applied, and a plaster cast extending from the nipple line to the ankle on the affected side. The patient is returned to bed and 20 pounds of weight are applied for traction in a direct

Fig. 266.—Fracture of pelvis with central dislocation of hip.

Fig. 267.—Same as Fig. 266. After reduction.

line. The weight may be increased later to 30 pounds. Traction is continued for three weeks, when the cast is changed, the limb examined, and roentgenograms made. If the position is satisfactory, a cast is reapplied and traction continued in the same manner for two or three weeks longer, when a Thomas caliper brace is applied and walking permitted. The results of this simple treatment are most satisfactory. Traction laterally may be used in addition, and skeletal, and other types of traction, may be employed when the above procedure fails. Open operation is rarely necessary. A special cast, with pressure over the adductor muscles against the pelvis or perineum, as advised by Albee, may be of value.

Fractures of the Spine

Fracture of a vertebra may involve the body, the neural arches (the pedicles or laminae), the transverse, spinous, or articular processes. The body is more frequently fractured than any other portion of the vertebra. As the spinal cord is enclosed and protected by the spinal column, injury of the cord by hemorrhage, crushing, laceration, or complete severance is not uncommon. The spinal cord is composed of delicate tissue, and even slight injury may produce permanent impairment. The danger of paralysis is greater in proportion as the site of the fracture is higher in the spine. Fractures of the spine are usually caused by forcible flexion of the trunk or severe falls upon the buttocks. They are often associated with fractures of the extremities.

The symptoms of fractures of the spine may not be apparent at the time of injury, unless paralysis is present. The patient will complain of a general soreness and stiffness of the back. Pain may not be present, but usually occurs after a few days with increasing stiffness. On examination a definite prominence of one of the spinous processes may be present, and in fractures of the neural arches, contusion, ecchymosis, and subcutaneous hemorrhage may be apparent. The diagnosis is made by the roentgenogram which should be employed whenever there is injury of the spinal column. Both views of the entire spine should be made and stereoscopic films of the lumbosacral area when symptoms are referable to this region. The lateral view will demonstrate fractures of the vertebral body more clearly than the anteroposterior view. Neurological symptoms of a functional type may persist after injuries of the spinal column. Whether this is due to hysteria, malingering, or to an obscure organic lesion of the central nervous system is difficult to determine. Fractures of the different regions of the spine will be discussed separately.

The Lumbar Vertebrae.—Fracture of the body of the first lumbar vertebra occurs more frequently than fracture in any other region of the spine. This is probably due to the fact that the pressure is greatest at this point when the spine is forcibly flexed. Fractures of the bodies of the vertebrae are usually compression or impacted fractures; the body is compressed from above downward and becomes wedge shaped with the base posteriorly. Rarely, the bone is crushed and a gradual change in contour occurs from the superincumbent weight, so that wedging may not be apparent immediately after the fracture, but only after weeks or months. The fracture may be com-

minuted with displacement of the fragments laterally or anteriorly; dislocation of the body may also occur.

The principle of treatment of fractures of the bodies of the vertebrae without paralysis is hyperextension and immobilization. This may be accomplished on a Bradford frame with insertions of heavy felt pads under the affected region until the spine is hyperextended. Traction is also applied to both lower extremities. A body cast may be applied with the spine in hyperextension, or if complete immobilization is desired, the hips must be included by employing the double spica continuous with the body cast. At the end of the eight weeks, a brace or jacket is applied and the patient permitted to walk; the brace is worn for six months or a year. Permanent relief is obtained in a ma-

Fig. 268.—Compression fracture of second lumbar vertebra. Anteroposterior view.

Fig. 269.—Same as Fig. 268. Lateral view.

jority of those in whom appropriate measures have been instituted early; however, pain and disability may persist, regardless of the efficacy of treatment. In this class, fusion of the affected region of the spine is indicated by one of the methods described in the chapter on Tuberculosis.

Fractures of the transverse processes of the lumbar vertebrae are usually caused by forced side-bending, opposite from the side on which the fracture occurs. One or all of the processes may be fractured, the line of fracture being transverse, from above downward, or in the long axis of the process. The symptoms are tenderness, soreness, and stiffness in the muscles surrounding the spinal column. The diagnosis is made only by the roentgenogram. The treatment consists of rest on a Bradford frame, with traction to both lower extremities for six weeks, followed by a spinal brace which should be worn from three to six months. Unless such measures are instituted early, symptoms may persist permanently.

The Dorsal Vertebrae.—Fractures of the dorsal vertebrae are more frequent in the lower dorsal region; compression fracture of the eleventh dorsal vertebra being next in frequency to fracture of the first lumbar vertebra. Fractures of the upper dorsal vertebrae are less common and are often unrecognized unless there is involvement of the spinal cord. Fractures of the transverse processes in the dorsal region are very rare, but fractures of the ribs adjacent to the transverse processes are probably caused by the same forces which bring about fractures of the transverse processes in the lumbar region. Fractures of the neural arches alone are rare and are usually attended with symptoms of spinal cord injury. The treatment of fractures of the dorsal spine is similar to that of the lumbar spine, except that head traction is required when the fracture is above the eighth dorsal vertebra and also a head support must be attached to the spinal brace when ambulation is permitted. Braces are continued for at least six months, and if symptoms persist after their removal, spinal fusion is indicated by operative methods.

The Cervical Vertebrae.—Fractures of the cervical spine may not be recognized, and undoubtedly fractures of this and all regions of the spine may occur and progress to complete recovery without treatment when the spinal cord is not involved. However, fracture of the cervical spine must be regarded as a serious injury. The symptoms are pain and rigidity of the muscles of the neck. Torticollis may be present. In fracture of the atlas or axis rotation, as well as flexion of the neck, is markedly limited. On palpation and inspection a definite

kyphos will be observed. A persistent neuritis with pain down the arms may result from nerve root irritation. The roentgenogram will reveal the nature and extent of the fracture. Two views must always be made; in fractures of the body, the lateral view shows definite compression, and often displacement anteriorly of the adjacent vertebrae. Fractures of the laminae and spinous processes are rare, but are demonstrated to better advantage by the lateral view. The treatment of fractures of the cervical vertebrae consists in immobilization on a Bradford frame and head traction. Manual reduction under anesthesia has been advised, but there is grave danger of serious injury to the spinal cord. Head traction is continued for six or eight weeks, after which a spinal brace with head support is applied and worn for six months to one year. The prognosis is good if treatment is begun early. In those in whom treatment is delayed, neuritis may persist with pain and swelling in the hands. Operative fusion is very rarely indicated, as recovery of fractures of the cervical spine without cord involvement is usually complete after efficient orthopedic measures.

Fig. 270.—Fracture of cervical spine. Note forward displacement of head on neck.

Injury to Spinal Cord.—In spinal cord injury following fractures of the spine with cord involvement, the indications for treatment depend upon the symptoms. When there is only a slight paralysis or weakness, conservative measures are instituted and the patient closely observed. If the paralysis is increasing, hemorrhage is the probable cause, and a laminectomy should be performed. In those with complete paralysis, observed within the first twenty-four hours after the injury, immediate laminectomy is indicated. The earlier the operation, the better is the chance for recovery of function; after complete paralysis has existed for twelve hours, the prospect of regaining function is slight; and after three days the probability is practically nil. However, if there is an obstruction in the spinal canal, as indicated by the Queckenstedt test, a laminectomy should be performed.

Queckenstedt's Test.—The Queckenstedt test is based upon the fact that compression of the jugular veins causes an increase in intracranial and intraspinal pressure. A lumbar puncture is done and the pressure

of the spinal fluid noted by a mercury manometer attached to the needle. The normal pressure varies from 8 to 12 mm. of mercury. Compression of the jugular veins is then made by pressure on each side of the neck. If the spinal canal is patent there will be an immediate rise in pressure as indicated by the manometer, which is followed by a return to normal as soon as the pressure on the veins is released. If a manometer is not available, the increase of pressure may be observed less accurately by noting the change in rapidity of flow of the spinal fluid from the needle.

Laminectomy.—The incision proportionate to the predetermined number of laminae to be removed should be made long enough to include at least one spinous process above and below the contemplated opening, since it so often happens that one additional lamina above or below may have to be removed. The incision in the intervertebral fascia is made with a heavy knife and should penetrate the muscular sheath. The separation of the muscular layer from either side of the spines and from the laminae may be done rapidly with a broad chisel. Retractors are inserted and the blades separated sufficiently to bring into view the articular processes on either side. The interspinous ligaments having been divided with a heavy-bladed knife above and below, the several spinous processes are removed one by one with bone-cutting pliers and the corresponding laminae with rongeur forceps. While the cord is protected throughout the spinal canal by the epidural fat and in the lumbar region by the subflavous ligament, care must be taken to avoid injuring the cord in the removal of the laminae. Hemorrhage from every source should be under control before the dural sac is entered. To open the dura introduce two silk traction sutures, one on either side of the median line, mounted on small curved needles, which enter the dura but do not penetrate it. Slight traction upon these sutures frees the dura, and between them a minute incision is made with a small scalpel down to, but not including, the arachnoid. The dural incision is lengthened by cutting over a director first in one direction, then in another. The operator pauses now to inspect the field, and with the arachnoid still intact, his observations may give a clew to the site and character of the lesion. Under normal circumstances the cerebrospinal fluid pulsates synchronously with the pulse and with respiration. This natural phenomenon may not be present if the subarachnoid space above the opening be so obstructed that free communication is interrupted. With this preparation the operator is prepared to inspect the meninges, roots, and cord, and the subsequent steps of the operation will depend upon the nature of the lesion. When

the patient is completely paralyzed before the operation, the question of his becoming ambulant depends more upon the extent of the cord injury than upon the number of laminae removed. All layers of the wound are closed.

Fractures of the Sternum and Ribs

Fractures of the sternum are rare, but when present constitute serious and often fatal injuries. When the fragments are not displaced an adhesive plaster dressing is the only adaptable type of splint. In those with gross displacement open reduction may be required. Fractures of the ribs are of frequent occurrence, and may result from various types of injury in which the chest wall is traumatized. The most common type is a transverse fracture without displacement of the fragments. Such a fracture may not be easily demonstrated by the roentgenogram, especially in the early stage; often the formation of callus may be the first definite evidence of a fractured rib. One or several ribs may be fractured with overlapping and penetration of the pleura and lung. Localized pain and tenderness is present and respiration may be shallow, due to exaggeration of pain on each inspiration. Emphysema of the subcutaneous tissues may follow injury of the lungs.

The treatment of fractures of the ribs consists of immobilization of one half of the chest wall by the application of an adhesive-plaster dressing. The arm on the affected side is elevated and the patient requested to take a deep breath. As the air is expelled, the first adhesive strip is placed snugly about the thorax, beginning posteriorly 2 or 3 inches beyond the midline, passing under the axilla and terminating anteriorly 2 or 3 inches beyond the midline on the side opposite to the fracture. Successive strips are applied in the same manner, overlapping each other, from above downward, until the entire half of the chest is encased. The bandage is trimmed under the axilla to permit free play of the arm. The adhesive dressing is changed once a week for three or four weeks. In fractures near or through the costal cartilages, the strapping may be required for eight weeks, and even after the most careful treatment, pain may persist indefinitely. This is possibly due to the slow healing of cartilage from its normally decreased circulation as compared to bone.

BIBLIOGRAPHY

Cotton, F. J.: Artificial Impaction of Hip Fractures, Ann. Surg., 63: 366, 1916.

Whitman, Royal: Orthopedic Surgery, Ed. 8, Phila., Lea & Febiger, 1927, pp. 902, 957.

Wilson, P. D.: Treatment of Fracture of the Os Calcis by Arthrodesis, Jour. Amer. Med. Assoc., 89: 1676, 1927.

CHAPTER XI

FRACTURES (*Continued*)

Fractures of the Clavicle

Fractures of the clavicle are common, being more frequent in childhood than fracture of any other bone. In children the fracture is often of the greenstick type. The cause may be direct violence, but is usually indirect violence by a fall upon the outstretched hand or shoulder. The site of fracture may be the inner, middle, or other third of the clavicle. The most common fracture is that of the outer third with definite separation and overlapping, the outer fragment being carried downward by the weight of the upper extremity, while the proximal fragment is pulled upward by the sternocleidomastoid muscle. Fracture of the inner third of the clavicle is rare and occurs practically always in adults above middle age. The attitude is characteristic. The shoulder is depressed downward and forward; the head is inclined toward the affected side and the patient supports the arm with his uninjured hand. There is swelling and tenderness over the point of fracture, and pain and crepitus on motion of the arm. On palpation, overlapping of the fragments may be detected. The roentgenogram demonstrates the fracture and shows the displacement. The diagnosis is not difficult, but may be overlooked in the greenstick variety, if a roentgenogram is not made.

Reduction of fractures of the middle and outer thirds of the bone is accomplished by elevation of the arm and shoulder outward and backward. The Sayre adhesive dressing is the most convenient method of maintaining this position. A pad of cotton or felt is placed in the axilla. The first strip of adhesive is applied about the arm, passed across the back, under the sound axilla, and on to the chest anteriorly, drawing the shoulder backward. A second strip is then carried from the affected shoulder down the posterior surface of the arm, around the elbow and across the chest to the opposite shoulder, drawing the elbow and forearm forward and elevating the shoulder with the distal fragment of the clavicle. The point of the olecranon process must be well padded, and the adhesive tape must be applied snugly enough to hold the fragments in position, but not so tightly as to interfere with

the circulation of the arm. A gauze bandage is applied to retain the adhesive strips in position. In young children reduction is often not necessary, as good function is secured by simple splinting. Reduction may be accomplished under anesthesia by grasping the fragments,

Fig. 271.—Fracture of the clavicle with overriding of fragments.

angulating and locking them, if possible, after which the Sayre adhesive dressing is applied. If perfect approximation is desired, recumbency on a Bradford frame for a period of three weeks is necessary. The Sayre dressing is then continued for two weeks, after which a convalescent splint consisting of two padded shoulder straps attached to

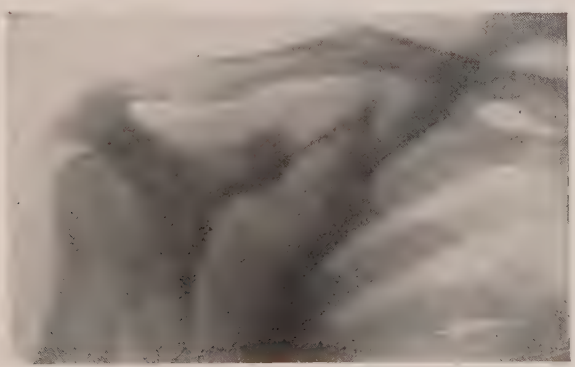


Fig. 272.—Same as Fig. 271. After reduction.

an adjustable posterior strap, is used, the object of which is to hold the shoulders backward to maintain normal length of the clavicle.

In many instances perfect reduction can not be accomplished and an unsightly protuberance results, but a good functional extremity is obtained despite deformity. In such cases, especially in young

girls, in whom a good cosmetic effect is desirable, an open operation is indicated. A linear incision just below and parallel with the clavicle is made. The ends of the bones are reduced and the apposition maintained by sutures passed through drill holes in the fragments. Silver wire or steel wire may be employed. The after-treatment is similar to that following closed reduction, the Sayre adhesive dressing being employed. Even after open operation there is a tendency toward angulation from gravity traction of the upper extremity, and conse-

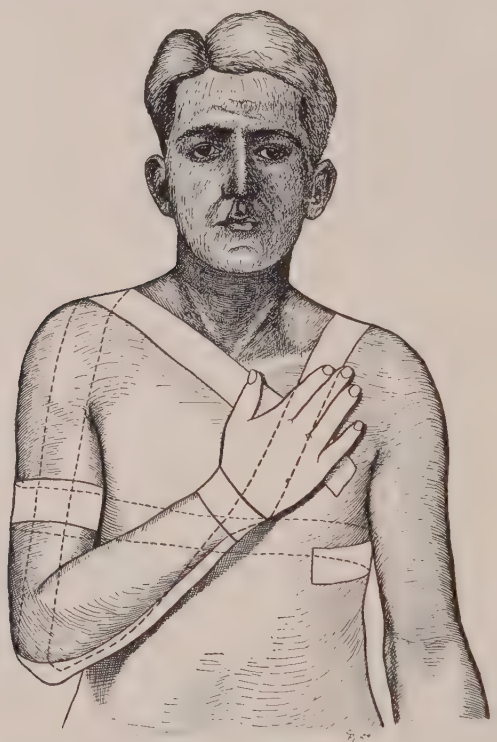


Fig. 273.—Method of applying Sayre adhesive dressing.

quently, the reclining position is advisable for several weeks. In fractures of the inner third, the outer fragment is displaced upward and the inner downward. Reduction of this fracture is easier to maintain, but may often be impossible to secure; consequently open operation is frequently indicated.

There is no ambulatory measure that will hold fractures of the clavicle in apposition, but the barrel-stave splint may give excellent results, although accurate approximation of the fragments can not be so maintained. The splint is made from a barrel-stave 3 inches in

width, the length being equal to the distance between the shoulders. A nail is driven into each of the four corners of the splint. The splint is applied to the posterior aspect of the shoulders, crossing the scapulae; a figure-of-8 bandage incorporating the nails is placed about the shoulders with both shoulders held backward. The splint is adjusted about once a week and should remain in place continuously for three weeks. As good functional results are secured in children, even when displacement persists, this measure has proved satisfactory. A T-splint is also employed and consists of a horizontal bar, which passes from shoulder to shoulder posteriorly, connected to a perpendicular piece which passes down the spine and which may be supported by a pelvic band. Otherwise, a Taylor spinal brace may be employed with a transverse limb which extends posteriorly to the shoulders and acts in the same manner as the barrel-stave splint.

Funston has recently described an ingenious splint for treatment of fracture of the clavicle. The splint is constructed of a heavy steel wire band bent to conform to the contour of the body passing under the axillae with pads over each shoulder. This bar is fastened posteriorly to upright bars which in turn are attached to a pelvic strap or band. The apparatus is entirely retained by one strap which encircles the waist. By the lever action of the brace the strap controls the force of the correction. Pressure is exerted against the heads of the humeri by means of drums, thus avoiding any unnecessary constriction.

Fractures of the Humerus

The Upper Extremity.—The common fractures of the upper extremity of the humerus consists of: (*a*) Fracture of the head, (*b*) fracture of the anatomical neck, (*c*) fracture of the surgical neck, (*d*) fractures of the tuberosities, and (*e*) separation of the epiphysis.

Chip fractures of the head or splitting of the articular surface may accompany luxation of the shoulder or may occur independently. If reduction can be secured manually or by open operation, union will occur, but the subsequent enlargement of the head causes some impairment of motion. If the fragment is widely separated and can not be reduced successfully, it should be excised. Fracture of the anatomical neck involves the portion of the humerus between the head and the tuberosities. In fractures of both the anatomical and surgical necks, the head may be dislocated, requiring open reduction to replace the head in the glenoid cavity. In fractures of the anatomical neck without dislocation, reduction is accomplished by moderate abduction to about 60 degrees and internal rotation. A plaster cast is applied

or a traction humerus splint may be employed. In fractures of the surgical neck, the distal fragment is displaced forward and inward by the pull of the pectoralis major muscle, causing a peculiar appearance of the shoulder as if the articulation had been transposed forward.

Fig. 274.—Fracture of head of humerus.

Fig. 275.—Same as Fig. 274. After reduction.

An erroneous diagnosis of dislocation is often made with attempts at reduction, when no dislocation exists. Manual reduction may usually be accomplished by angulation at the line of fracture; engagement

Fig. 276.—Fracture of surgical neck of humerus.

Fig. 277.—Same as Fig. 276. After reduction.

of the fragments can be felt and the roentgenogram will confirm satisfactory approximation. Reduction of this fracture at times can not be accomplished due to interposition of the tendon of the long head of the biceps muscle between the fragments. An anterior incision is

made through the deltoid muscle; the tendon is disengaged and the distal fragment aligned into position. Stability is usually secured by simple reduction, but internal fixation may be required. After reduction, the humerus traction splint or a cast is employed and the results are universally satisfactory. Fracture of the greater tuberosity is more common than that of the lesser. Fracture of either tuberosity may be associated with dislocation of the shoulder and may be caused by direct or indirect violence or muscle contraction. The greater tuberosity is usually displaced upward, and the lesser inward. The treatment consists of fixation of the arm to relax the contracted structures; in fractures of the greater tuberosity the arm is abducted and in those of the lesser tuberosity the arm is flexed and adducted. Epiphysial separation of the upper humeral epiphysis is not infrequent. It is treated in the abducted position as a simple fracture of the surgical neck with excellent results.

Fig. 278.—Separation of upper humeral epiphysis.

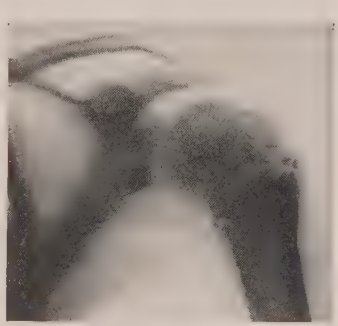


Fig. 279.—Same as Fig. 278. After reduction.

The Shaft.—Fractures of the shaft of the humerus may occur in the upper, middle or lower thirds, the upper third being more common. Transverse fractures are more frequent than oblique, spiral or comminuted. Reduction of transverse fractures is accomplished by angulation, end-to-end engagement, and fixation in an effective retention apparatus. The oblique fractures are reduced by rotation and traction until approximation is secured. Fractures of the middle third are more often comminuted, and a loose fragment may be detached from the shaft by torsion. For fractures of the upper and middle thirds, the traction humerus splint or a plaster cast may be employed. The traction apparatus allows gradual reduction of the oblique and comminuted fractures while permitting ambulation at the same time. Suspension traction and skeletal traction may also be employed, but have the disadvantage of confining the patient to bed.

Fractures of the lower third of the shaft may be transverse or oblique. The lower fragment is always displaced forward, and therefore injury of the brachial artery may occur. The vessel is particularly endangered when the elbow is extended. All fractures in this region, therefore, should be temporarily splinted with the elbow flexed. Injury of the musculospiral nerve is a not infrequent complication of fractures of the middle and lower thirds of the humerus. This causes wristdrop with lost or diminished sensation over the area supplied by the nerve, and if the symptoms do not improve rapidly, the musculospinal nerve should be explored, as continued pressure may cause permanent impairment. Fractures of the lower third should be reduced in the same manner as fractures of other portions of the shaft. After

Fig. 280.—Fracture of shaft of humerus. Anteroposterior view.

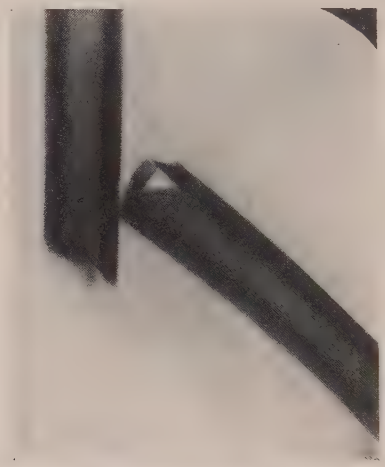


Fig. 281.—Same as Fig. 280. Lateral view.

approximation, a modification of the traction humerus splint is employed, as described in the chapter on Apparatus.

The Lower Extremity.—Fractures of the lower extremity of the humerus involve the elbow joint, either directly or indirectly. As in the lower extremity of the femur, fractures of the lower extremity of the humerus may be classified as (*a*) supracondylar, (*b*) fractures of the internal condyle, (*c*) fractures of the external condyle, (*d*) T-fractures, (*e*) comminuted fractures, and (*f*) epiphyseal separations. Fractures about the elbow may be caused by various types of trauma, as indirect force, by falling on the outstretched hand; torsion by twisting of the forearm in flexion; and direct force by falling upon the elbow. As the elbow is a superficial joint, swelling may soon obscure the osseous landmarks,

rendering physical examination difficult and the conclusions derived therefrom uncertain. As the mechanism of the elbow joint is very

Fig. 282.—Fracture of shaft of humerus after reduction. Anteroposterior view.

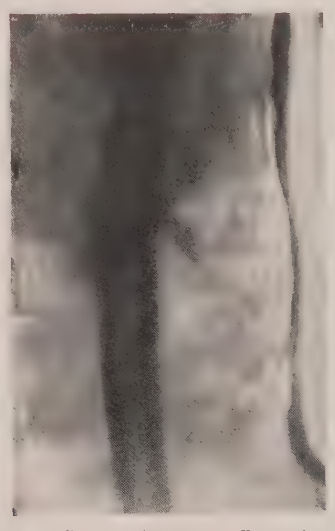


Fig. 283.—Same as Fig. 282. Lateral view.

complex, being a double joint, and as the articular surfaces conform closely to each other, accurate reduction is necessary; the slightest

Fig. 284.—Supracondylar fracture of humerus. Anteroposterior view.

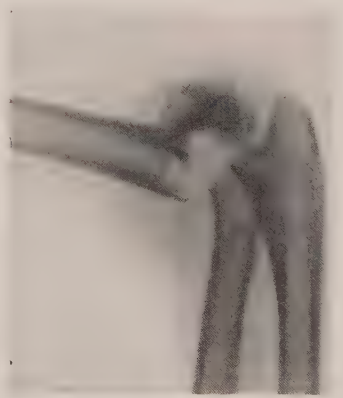


Fig. 285.—Same as Fig. 284. Lateral view.

rotation of the fragments may seriously and permanently impair function.

Supracondylar Fracture.—The most frequent type of fracture of the lower extremity of the humerus is the supracondylar, which is a more or less transverse fracture through the cavernous bone above

Fig. 286.—Supracondylar fracture of humerus after reduction. Anteroposterior view.

Fig. 287.—Same as Fig. 286. Lateral view.

the epiphysis; this must not be confused with epiphyseal separation. The lower fragment is displaced backward by the pull of the triceps

Fig. 288.—Loss of carrying angle at right elbow following fracture of humerus.

muscle, and inward by gravity. Rarely the opposite displacement is observed, the lower fragment being displaced forward upon the shaft of the humerus, and overlapping the proximal fragment.

Supracondylar fractures are more common in middle childhood, occurring between the ages of five and ten years. Reduction is accomplished by first extending the elbow and making direct traction; the lower fragment is palpated and stabilized with the thumb of the right hand. The elbow is then flexed gradually while forward pressure is made upon the lower fragment. Full flexion is secured. If the relation of the condyles to the olecranon process is not normal, the lower fragment may be shifted by grasping the condyles. An anteroposterior and a lateral roentgenogram is made; the anteroposterior is made with the film posterior to the joint; focusing the rays through the flexed ulna and radius. Perfect reduction in both views should be obtained; only slight failure of approximation is permissible. The relation of the condyles to each other and to the olecranon must be restored to normal, otherwise there may be loss of the carrying angle with cubitus varus. Flexion alone does not always reduce the fracture; the external contour may be apparently normal, while the roentgenogram shows gross displacement. After reduction is confirmed, cotton padding is placed in the fold of the elbow to prevent excoriation of the skin, and adhesive strips are placed about the arm and forearm to maintain the acutely flexed position; a gauze bandage is placed about the entire extremity, including the hand, to prevent swelling. The radial pulse must be palpated before and after reduction. In some instances, the pulse is obliterated by the injury or may become so after the reduction. In such cases the fingers should be carefully observed for impairment of circulation. In those not observed until there is excessive swelling, partial reduction should be accomplished under general anesthesia, after which gradual correction until full flexion is secured will accomplish complete reduction. At the end of ten days the dressing is changed and roentgenograms made; if displacement has occurred, reduction can be accomplished again; otherwise, the elbow is held in the flexed position for another ten days, depending, to some extent, upon the age of the patient. In very young children the period of immobilization may be shortened. At the end of three weeks the adhesive dressing is removed, the forearm extended as far as possible, and a simple right-angle elbow-splint applied. If there is 15 degrees free motion, perfect function may usually be expected. Active and passive movements are instituted together with physiotherapy. Prolonged convalescence may be expected in all fractures about the elbow joint. However, active use alone will usually restore perfect function in from thirty to ninety days, depending upon the age of the patient. When there is anterior displacement of the lower fragment, reduction

is accomplished by extension and backward pressure, after which the elbow is placed in the flexed position. If satisfactory reduction cannot be obtained after a second or third manipulation, open operation is indicated.

Internal Condylar Fracture.—Fractures of the internal condyle may or may not involve the trochlear surface. The fragment is displaced inward, and often downward, due to the contraction of the conjoined attachment of the flexor muscles to the epicondyle. Reduction can usually be accomplished by lateral pressure and flexion of the joint. If accurate reposition is not obtained, an open incision is required to approximate the surfaces which are retained by a wire nail, beef-bone screw, or suture. Fracture of the internal epicondyle with displacement downward is common, and unless complicated no treatment may

Fig. 289.—Fracture of external condyle of humerus with wide separation. Anteroposterior view.

Fig. 290.—Same as Fig. 289. Lateral view.

be necessary. Rarely, this fragment becomes folded inward with the capsule of the elbow joint, and is held by this structure in close approximation to the lower surface of the sigmoid cavity of the ulna, between the trochlear surface of the humerus and the ulna. When such a complication exists, an incision is made into the joint, and the capsule and epicondyle are extricated and sutured into their normal positions. Active motion is instituted together with passive motion and massage.

External Condylar Fracture.—In fractures of the external condyle the fragment is displaced outward and often rotated. Successful reduction may rarely be accomplished manually, as the fragment must be accurately replaced; otherwise, nonunion of this terminal fragment occurs, causing a lax and maldeveloped elbow joint. An incision is made on

the posterolateral aspect of the joint, the fragment is approximated and a wire nail placed through the fragment into the adjacent shaft to maintain the reduction. The steel nail in this location is well tolerated and gives excellent stability, although other measures for internal fixation may be employed. Fracture of the external epicondyle is very unusual and requires no treatment.

T-fractures of the lower extremity of the humerus are similar to those occurring in other long bones and consist of a transverse fracture above the condyles, with a longitudinal fracture separating the condyles. Both condyles may be markedly displaced and there may also be associated comminution. Reduction may be accomplished by lateral pressure and traction, but, as a rule, an open incision is required. The

Fig. 291.—Fracture of external condyle of humerus with wide separation. After reduction. Anteroposterior view.

Fig. 292.—Same as Fig. 291. Lateral view.

condyles are aproximated and transfixed with a nail or bone peg; the horizontal fracture may then be reduced. A cast or splint is applied, including the entire arm and chest, to prevent rotation of the arm.

Comminuted fractures may be so extensive that anatomical reduction is impossible. In such instances, massage and physiotherapy, with active and passive movements at regular intervals, should be instituted as early as possible. If ankylosis ensues, an arthroplasty may be indicated later.

Epiphyseal Separations.—Separations of the entire lower epiphysis, of the external condyle, or the internal epicondyle alone may occur. The former is rare and is possible only up to the age of four years. Reduction is usually satisfactory with excellent results. However, epiphyseal injuries may be followed by a permanently impaired joint.

Fractures of the Forearm

Fracture of the bones of the forearm may occur singly or both the radius and ulna may be involved. The important fractures of the radius are those of the head, the shaft, and the lower extremity. The olecranon process of the ulna, the coronoid process, the shaft, or the lower extremity may be fractured.

The Radius.—Fractures of the head of the radius may be linear or depressed without displacement; transverse with displacement of the head, or comminuted. In linear and depressed fractures of the head, physiotherapy instituted at once is usually the only treatment necessary. In transverse fractures of the neck with displacement of

Fig. 293.—Fracture of head of radius.

Fig. 294.—Fracture of olecranon process of ulna.

the head, manual reduction may rarely be accomplished; open reduction is often necessary and fixation with absorbable sutures is usually sufficient. In extremely comminuted fractures, excision of the entire head above the attachment of the biceps muscle is indicated. The result as to restoration of functional rotation is uncertain. When fracture of the radius occurs just below the bicipital tuberosity, reduction may be difficult or impossible, due to the constant contracture of this muscle and open reduction may be required.

The Ulna.—Fracture of the olecranon process of the ulna is treated in the same manner as fracture of the patella. Approximation may rarely be secured by extension of the elbow, but in young individuals

open reduction with internal fixation by kangaroo-tendon sutures, nails or silver wire is indicated. In patients above fifty years of age,

Fig. 295.—Fracture of shaft of ulna and dislocation of head of radius. Anteroposterior view.

Fig. 296.—Same as Fig. 295. Lateral view.

the best results are secured by immediate mobilization and physiotherapy. Fractures of the coronoid process may require open reduction

Fig. 297.—Fracture of ulna and dislocation of head of radius. Anteroposterior view.

Fig. 298.—Same as Fig. 297. Lateral view.

and are a serious complication when associated with fractures of the olecranon process. Fracture of the ulna just below the sigmoid cavity is often associated with dislocation of the head of the radius. Both

the dislocation of the radius and the fracture of the ulna must be accurately reduced, or function of the elbow will be seriously impaired; open reduction is indicated if manual manipulation fails.

The Radius and Ulna.—Fractures of the shafts of the radius and ulna may occur in the upper, middle or lower thirds; when both bones are fractured, reduction is accomplished by considering them both as one bone. Traction and angulation are made until the fragments are engaged. If the radius is reduced, the results should be satisfactory. If manual reduction is impossible, small incisions may be made over the points of the fractures and the fragments of the bones engaged by

Fig. 299.—Fracture of both bones of forearm. Anteroposterior view.

Fig. 300.—Same as Fig. 299. Lateral view.

using a blunt instrument. Internal fixation may be required. In fractures of both bones of the forearm, except certain fractures of the lower third, the fixation apparatus should be applied from the metacarpophalangeal joints to the shoulder, so as to prevent rotation of the forearm. Suspension of the arm from an overhead frame is at times of value in securing reduction of fractures of both bones which is otherwise difficult to maintain. Adhesive traction is applied to the anterior and posterior surfaces of the forearm and the arm suspended by a system of weights and pulleys. Countertraction may be made, but the weight of the arm alone is usually sufficient.

Colles' Fracture.—Fracture of the lower extremity of the forearm is of very common occurrence, the most frequent type being that

Fig. 301.—Roentgenogram showing fracture of both bones of forearm after reduction. Anteroposterior view.

Fig. 302.—Same as Fig. 301. Lateral view.

known as Colles' fracture, which is produced by a fall upon the outstretched hand or by a direct force against the palm of the hand, as

Fig. 303.—Colles' fracture. Anteroposterior view.

Fig. 304.—Same as Fig. 303. Lateral view.

in cranking an automobile. The radius is broken $\frac{1}{2}$ to 1 inch above the wrist and the distal fragment is displaced backward; the tip of the styloid process of the ulna is often broken or the internal lateral

ligament of the wrist joint may be lacerated. The radio-ulnar ligament is usually torn and the head of the ulna displaced forward. If the force is great, the head of the ulna may penetrate the skin. Comminution and compression or impaction of the lower radial fragment may be a complication. The hand with the lower fragment is displaced backward and to the radial side which produces a typical deformity known as the silver-fork deformity because of its resemblance to a dinner fork. A similar deformity is also seen in dislocations of the wrist. Reduction is accomplished by first hyperextending the wrist, adducting it and then flexing it, making a downward push upon the lower fragment of the radius by the thumbs; gradually complete flexion is secured. After reduction the radial styloid should be on a lower

Fig. 305.—Colles' fracture, after reduction. Anteroposterior view.

Fig. 306.—Same as Fig. 305. Lateral view.

level than the ulnar styloid, which is the normal relation. A roentgenogram is made which must show restoration of the normal contour of the articular surface of the radius. The lower extremity of the radius normally faces the carpal bones directly; a moderate anterior inclination is permissible, but there must be no backward inclination or displacement of the lower fragment. When reduction is complete, the head of the ulna will assume its normal relation. The most efficient splint is a plaster cast extending from the palm of the hand to just below the elbow, with the wrist in extreme flexion, the cast is changed at the end of three weeks.

Anterior and posterior splints of wood or metal extending from the metacarpophalangeal joints to the elbow may also be employed effec-

tively, though the flexed position is more satisfactory. The lower end of the anterior splint is notched to allow space for the thenar

Fig. 307.—Fracture of lower thirds of radius and ulna in child. Anteroposterior view.

Fig. 308.—Same as Fig. 307. Lateral view.

eminence. Heavy felt pads are placed on the anterior aspect at the lower end of the upper fragment and on the posterior aspect over the

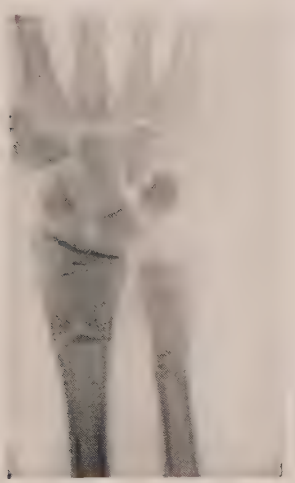


Fig. 309.—Fracture of the radius and ulna after reduction. Anteroposterior view.

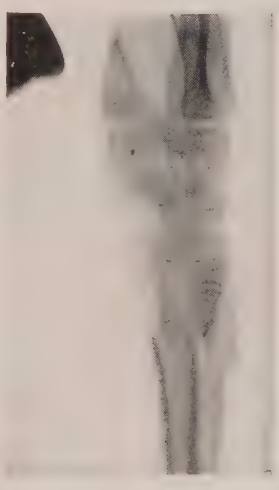


Fig. 310.—Same as Fig. 309. Lateral view.

metacarpal bones, as the splints are applied; backward pressure upon the upper fragment of the radius and pressure over the posterior sur-

face of the hand is thus made. Adhesive strips and gauze bandages maintain the splints snugly in position. In all fractures of the upper extremity, especially those near the wrist, the fingers should be free so that movement of all the phalangeal joints is permitted. Roentgenograms are made once a week to determine the relation of the fragments; should there be the slightest displacement of the lower fragment of the radius, a second reduction under anesthesia is indicated. At the end of three weeks physiotherapy is instituted, but the anterior splint is continued for two or three weeks longer.

Rarely, the displacement of the Colles fracture is reversed and the lower fragment of the radius is displaced forward. Reduction is accomplished by manipulations in the opposite directions to those described for the ordinary type of Colles' fracture. Anterior and posteror wooden splints are applied, without felt pads or with pads placed anteriorly to the lower fragment; the after-treatment is similar to that of Colles' fracture. Colles' fracture in children is very rare; the same force induces fracture of the radius and ulna about 1 inch above the wrist with backward displacement of the lower fragments of one or both bones. Manual reduction is accomplished by the same procedure described for Colles' fracture, and the after-treatment is similar. If the radius can be satisfactorily reduced, perfect function may be expected, even though perfect approximation of the ulna may not be secured. Separation of the lower epiphysis of the radius is not uncommon during adolescence. The management is similar to that of Colles' fracture. The hyperflexed positionis preferable, as perfect apposition must be secured.

Fig. 311.—Chauffeur's fracture.

Chauffeur's Fracture.—The fracture of the lower extremity of the radius, known as chauffeur's fracture, is caused by the striking of the palm of the hand by the crank of an automobile. The line of fracture extends from a point about $\frac{3}{4}$ of an inch above the styloid process of the radius downward and inward to the articular surface of the radius, thus severing a triangular wedge-shaped portion of the bone from the

lower aspect of the radius; rarely is there any displacement. The treatment consists of immobilization for a period of two to three weeks.

Barton's Fracture.—A fracture of the posterosuperior portion of the articular surface of the radius is called Barton's fracture. The cause is a blow on the palm of the hand or wrist, or a direct crushing injury. The reduction and after-care are similar to that described for Colles' fractures.

Fractures of the Carpal Bones

Fracture of any one of the carpal bones may be produced by a fall upon the outstretched hand, or by any accident similar to that which would produce Colles' fracture. The scaphoid is fractured

Fig. 312.—Fracture of carpal scaphoid bone and dislocation of semilunar bone. Anteroposterior view.

Fig. 313.—Same as Fig. 312. Lateral view.

more often than any other of the carpal bones, and the line of fracture extends across the slender neck of the bone. The symptoms are similar to those of an ordinary sprain of the wrist, there being pain on all movement, especially on extension and radial flexion. Tenderness to pressure may be localized over the scaphoid bone and the most characteristic point of tenderness is in the anatomical snuff-box. A positive diagnosis can not be made without a roentgenogram. As union of the carpal bones is always delayed, and, as in the case of the scaphoid bone, union is practically always fibrous, the symptoms may persist indefinitely. When pain on motion continues, removal of one or both fragments of the scaphoid is indicated; the removal of the proximal fragment is usually sufficient. Injury of the semilunar bone may result in a rarefying osteitis, known as Kienboch's disease.

Fractures of the Metacarpal Bones

Fractures of the metacarpal bones are caused usually by direct violence. A frequent cause is striking a blow with the closed fist in fighting. The location of the fracture may be at the proximal end, at any point along the shaft or just behind the head of the bone, or the head of the bone itself may be crushed. Fractures of the shaft are often oblique with overriding and displacement of the fragments. In fractures of the proximal or the distal extremities, there is often comminution and impaction of the fragments. Traction in a "banjo splint" is a convenient and efficient method of immobilizing the part, and this traction also aligns the fragments in oblique fractures of the shaft.

Fracture just behind the knuckle may be determined on inspection by the loss of prominence of the metacarpal head when the hand is

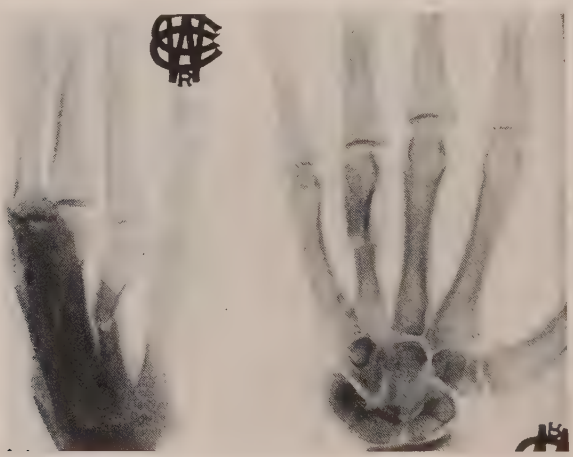


Fig. 314.—Fracture of fourth metacarpal bone.

clinched. Reduction is accomplished by strong traction on the corresponding finger and by direct backward pressure on the head of the bone. Perfect reduction is difficult and frequently impossible to maintain. The alignment may be secured by continuous elastic traction in extension on a "banjo splint" or by flexion of all the fingers about a roll of gauze or a felt pad placed in the palm of the hand. Open reduction may at times be necessary.

Fractures of the Phalanges

Fractures of the carpal phalanges are usually the result of direct violence in industrial accidents and consequently are frequently compound with laceration of the tendons and subsequent sepsis. Reduction

and immobilization are difficult, but the results of uncomplicated fractures are uniformly good, unless there is prominence of one of the fragments on the palmar surface of the fingers which prevents closure of the hand. The treatment consists of fixation in extension with or without traction. Physiotherapy is indicated in all injuries of the hand and fingers and active function should be encouraged as soon as possible.

COMPOUND FRACTURES

Compound fractures seen within the first two weeks following the injury are treated in a manner similar to simple fractures, provided there are no signs of infection at the time of examination. The skin surrounding the wound is thoroughly cleansed with sterile soap and water and painted with a 10 per cent solution of mercurochrome. Care is taken not to carry infection into the interior of the wound. One of the grave dangers is the introduction of infection from the outside into the depths of the wound by probes or similar instruments. All compound fractures are potentially infected, but, by no means do all actually become infected. After cleansing, the wound is covered with sterile gauze and the fracture reduced. In the presence of extensive lacerated wounds the treatment is the same, with the addition of thorough removal of dirt and other extraneous matter, such as particles of clothing and débridement of the devitalized tissues, being careful to remove only those tissues that are damaged beyond repair. A cast or a splint is applied, the patient carefully observed during the first ten days for symptoms of sepsis as evidenced by local pain and elevation of temperature. If no infection develops, the fracture is undisturbed for the usual period. If, however, there is reason to believe infection has developed, the wound is inspected. In the presence of a mild infection, it may not be necessary to remove the cast, but with a severe infection this must be done and some other type of apparatus applied.

When the fracture is infected at the time of the first examination the external wound is cleansed and a splint applied to immobilize the fragments. A wet dressing of $\frac{1}{2}$ to 1 per cent carbolic acid solution is applied, which is kept continuously warm. If the infection has subsided at the end of ten days, the fracture is reduced in the usual manner and a plaster cast applied. If the infection progresses during the first ten days, adequate drainage is established, either by enlarging the original wound or by counterincisions. Fragments of the bone are removed only when they have been thrown off as definite sequestra. It is a well established fact that bone fragments and even bone grafts

may live and be incorporated into a callus in the presence of an active infection. The danger of infection must not be underestimated and strenuous manipulations for reduction cause increased damage to the soft tissues. It is also poor surgical judgment to overestimate the danger and do an immediate extensive débridement. This unnecessarily traumatizes the soft parts and sacrifices bone fragments which may be needed to bridge the defect between the fractured ends and prevent shortening. Continuous traction by adhesive tape or skeletal traction and suspension are often employed in compound fractures, particularly gunshot fractures. This method was used extensively and successfully during the World War.

UNUNITED FRACTURES

Ununited fractures are those in which osseous fusion between the fragments does not occur. The condition is permanent and must be clearly differentiated from delayed union, in which osteogenesis, or the organization of callus into solid bone is abnormally retarded. In delayed union the process of healing is not progressing at the rate which is normal for the location and type of the fracture. The time required for union varies in the different bones, as well as in the individual patient; but, so long as the union is progressing, the fracture should be regarded as delayed; when a permanent stage, with organization of the exudate about the fragments is reached so that further osteogenesis is impossible, the condition is called nonunion or an ununited fracture. No definite time limit can be fixed after which nonunion is to be recognized. As a rule, if union is not advancing at the end of six months, the fracture is considered ununited. However, solid osseous fusion has been known to occur after a much longer period. The time in which nonunion is established varies in different locations, for example, central fractures of the neck of the femur should be considered ununited at the end of six weeks if the fragments have not been approximated.

Etiology.—The etiology of delayed and ununited fractures is the same. The causes are constitutional and local, the most influential being entirely local, as is proved by the fact that local treatment is successful in inducing union in a very high percentage. The constitutional causes are: (1) Focal infection, inducing a mild anemia or toxemia; (2) hypothyroidism and hyperthyroidism; (3) syphilis, rarely; (4) any debilitating diseases, as malaria, diabetes, etc., and (5) multiple fractures by overtaxing the ability of the body to produce callus so that union may be delayed or fail in one or two locations; (6) deficiency in

the blood calcium and blood phosphorus. The local conditions are: (1) Failure of reduction allowing wide separation of the fragments; (2) inadequate fixation and removal of apparatus before organization is complete; (3) interference with circulation by injury to the nutrient artery or by separation of the surrounding soft structures; (4) repeated attempts at reduction which inhibit the production of callus; (5) interposition of fascia and muscle tissue between the fragments which practically means failure of reduction; and (6) exposure of the fragments by compound wounds or operative incisions for open reduction. Union may fail in any fracture of the skeletal system, but nonunion occurs

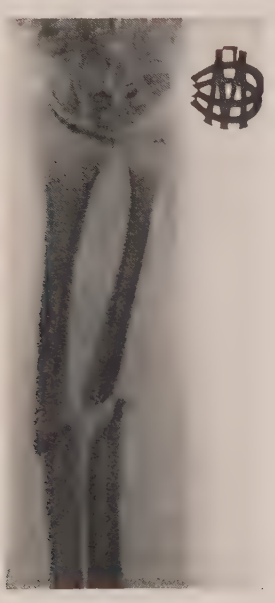


Fig. 315.—Ununited fracture of radius and ulna. Anteroposterior view.

Fig. 316.—Same as Fig. 315. Lateral view.

more frequently in terminal fractures, that is, when there is a relatively small fragment broken away from the rest of the bone, as in fractures of the external condyle of the humerus, and in central or intracapsular fractures of the neck of the femur. Nonunion of the shaft more frequently results in the humerus than in any other bone, possibly due to the difficulty in securing complete immobilization in fractures of the shaft of the humerus.

Pathology.—The pathology of ununited fractures consists in the condensation of callus upon the ends of the fragments with failure to bridge the defect with solid bone. The callus upon the proximal fragment, in the majority of cases, is in excess of that formed upon the

distal fragment, which results in the formation of a nodular prominence on the proximal fragment with a cavity into which the end of the atrophic distal fragment articulates. The distal fragment gradually forms a joint with the proximal fragment, each fragment being covered with fibrocartilage. There may be fibrous union between the surfaces, or a definite joint cavity may be formed by a bursal sac, with synovial fluid and joint capsule—the so-called pseudarthrosis. In some instances, there may be no reaction of the bone to form callus and the

Fig. 317.—Roentgenogram showing union of ununited fracture of radius and ulna after bone graft. Anteroposterior view.

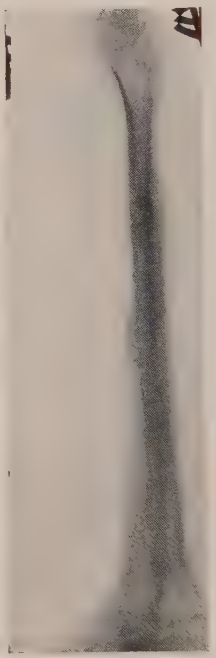


Fig. 318.—Same as Fig. 317. Lateral view.

fragments become atrophic, terminating in cone-shaped ends which are covered by dense fibrous cartilage and united by a band of fibrous tissue; at times, cartilage predominates over the fibrous tissue. Rarely, union may proceed until it is almost complete, but the area of fibrocartilage remains sufficient to permit slight movement between the fragments. Such a condition may persist for a period of six months or a year, and then become gradually replaced by osseous fusion, or the fracture may remain in a permanent state of nonunion. The roentgenological manifestations consist of osteoporosis or atrophy of both

fragments; bone atrophy is usually more pronounced in the lower fragment. Both fragments are tapered and their ends rounded by the proliferation of bone. The ends may be denser than normal by the condensation of callus, the bone appearing hard and eburnated. There may be excessive callus of a low-grade quality which does not seem able to penetrate the line of fracture.

Symptoms and Diagnosis.—The symptoms of nonunion are motion of varying degree between the fragments and impairment of function. In the type in which union is almost complete, motion is very slight and may be better demonstrated by the patient than by the surgeon. Pain on active use, lack of endurance, and swelling after ordinary use of the part, are constant symptoms. The diagnosis of an ununited fracture requires care in differentiating nonunion from delayed union, and the distinction must be made by the local physical signs and the roentgenogram. The prognosis in both conditions depends largely upon the efficiency of the treatment. Allowing for variations in the individual case, the results should be almost universally successful when judicious surgical measures are employed. However, the prospect of union decreases as age advances. The results by the average treatment are exceedingly poor; ununited fractures are frequently seen which have been subjected to five or more operative attempts to induce union.

Fig. 319.—Ununited fracture of humerus.

Treatment.—The constitutional treatment for delayed and ununited fractures is largely prophylactic. A careful physical examination should be made in all severe fractures for demonstration of foci of infection or other constitutional defects; it is possible that the removal of an infective focus may prevent the inhibition of the natural reparative process. The use of various drugs, as calcium, phosphorus and, extracts of the endocrine glands has been advised, but is of doubtful efficacy. Recent studies of the chemistry of the blood have demonstrated that the serum calcium in health is singularly constant in all mammals, although there is a slight variation with age. The product

of the concentration of calcium and phosphorus, as first suggested by Howland, in the diagnosis of rickets, may be employed in determining the prognosis of an ununited fracture. The usually accepted figure for serum calcium is 10 mg. per 100 cc. of serum. The inorganic phosphate in the serum or plasma is not as constant as the calcium and varies relatively more in children than in adults. The average figure for phosphorus in children is about 5 mg. per 100 cc. of serum, while that for adults is 3.5 mg. If the product of the calcium content, multiplied by the phosphorus content, is above 35, bone production should be normal; if the index is below 35, osteogenesis may be retarded. The calcium and phosphorus content of the blood may be determined, and if below normal, calcium salts and cod liver oil may be administered, as well as lime juice and orange juice.

Certain local measures may stimulate the production of callus in delayed union. Those most commonly used are Bier's hyperemia; pounding of the fragments with a hammer, using a felt pad for protection; maceration of the fragments against each other under anesthesia, after which the limb is immobilized and treated as a fresh fracture; and the injection of blood, iodine, and osmic acid into the point of fracture. All of these measures are of value, but the best possible treatment is functional use. In fractures of both bones of the leg, if union is progressing steadily, but is not firm at the end of six weeks, a second cast may be applied and partial weight-bearing permitted with the aid of crutches. At the end of one month, if union is firmer, another cast is applied, and weight-bearing increased by discarding the crutches. When motion between the fragments is barely perceptible, and there is no pain or instability when the knee is extended against the force of gravity, a steel brace is applied with a leather corset to support the limb firmly. This is worn until there is not only clinical consolidation, but organization of the callus into normal bone, as demonstrated by the roentgenogram. These principles should be employed in the treatment of all fractures; so long as callus is increasing conservative measures should be employed. Premature operations upon fractures with delayed union are too frequently performed.

When a fracture has reached the stage of nonunion, constitutional measures are of no practical value; the elimination of a focus of infection, or the elevation of the calcium and phosphorus content of the blood can have no effect upon the local process. Such measures must not be neglected, however, as the inhibitory factors may continue to act after the proper local measures have been instituted. The treatment of ununited fractures is essentially surgical. When there is wide separation

of fragments, approximation after freshening of the ends of each fragment with or without internal fixation may rarely be sufficient to induce union. Internal fixation by wire and metal or beef-bone plates is employed in ununited fractures, but such materials repel callus and osteogenesis, and are not so satisfactory as living bone grafts. In those in whom there has existed a previous pyogenic infection, as from compound fractures, or from previous operation, there is danger of relighting latent infection, also there is great danger from infection in low-grade nonresistant scar tissue which may be the sequela of such a condition. No operative procedure should be advised until at least six months or one year has elapsed after the complete subsidence of all evidence of an infectious process. In those in whom a superficial scar remains a preliminary skin plastic procedure is often necessary, for the transplanted bone should be covered by as much normal soft tissue as possible. After operation, protection by apparatus is absolutely necessary until union is solid and completely organized, often as much as six months is required before function can be permitted without apparatus. Unless protected a sufficient length of time, fracture of the graft with recurrence of the ununited fracture is not uncommon.

Bone Grafts.—Bone transplants derived from the same individual are known as autogenous transplants or grafts; those taken from another member of the same species, as from man to man, are called homogeneous transplants; transplants taken from another species of animal are called heterogeneous. Autogenous bone grafts are more efficient and will produce union in a large percentage in a shorter period of time. Homogeneous bone grafts are rarely employed, but on rare occasions may render excellent results possible. When they are used the grafts should be removed from the patient's mother or other near relative, and the blood of the recipient and donor should be examined for compatibility in type. The heterogeneous bone transplant has been discarded, as have heterogeneous skin transplants. Beef bone, or bone from other animals is specially prepared as splints for the purpose of internal fixation. These are often called grafts, but, as a matter of fact, they are foreign bodies and do not aid in bone production any more than catgut or kangaroo-tendon sutures.

There are three theories concerning the action of a free autogenous osseous transplant: (1) That it lives and becomes adapted by functional use to its new location; (2) that the transplant dies en masse, but acts as a scaffold or framework into which new bone grows until the size and shape of the transplanted bone is reproduced; (3) that a

portion of the cells within the transplant dies, new bone being formed by the cells that survive; by division of the cells in the graft and those in the adjacent bone continuity is established between the transplant and the surrounding osseous tissue. There is also a difference of opinion among physiologists and surgeons as to the part played by the periosteum in the reproduction of new bone. Some claim that the periosteum is merely a limiting membrane or capsule and has no other function; others believe that the periosteum is rich in reproductive power or osteogenesis. In the inner stratum of the periosteum osteoblasts or bone-producing cells are abundant; this layer may be considered either as the outer layer of the bone or as the inner layer of the periosteum. Most surgeons transplant the bone with the periosteum attached, in order to be certain to include all of the bone-forming elements. In transplanting bone, the surface of the graft should be closely approximated to the denuded surface of the living bone and the graft fixed as securely as possible. The author believes that there are three important factors to be considered if the highest percentage of successful osseous union is to be secured. These are: (1) Rigid asepsis, (2) perfect internal fixation, and (3) osteogenesis. The technic should be faultless. No one surgeon is able to carry out the technic required, and a team of well-trained associates is necessary. Instrumental technic, as described by Lane, is advisable, if not absolutely essential. Especial care should be taken in the handling of soft structures, particularly the periosteum; tearing loose of muscle and other soft tissues should be avoided.

Ununited fractures are more successfully treated by autogenous bone grafts, but there is a difference of opinion as to the best type of graft to employ. Transplants are more often taken from the internal subcutaneous surface of the tibia on account of convenience, and because a large piece of bone may be secured from this area without danger of impairing function. There are several types of autogenous grafts routinely employed to meet the requirements of various surgical procedures in ununited fractures, *i. e.*, (1) the massive graft; (2) the inlay graft; (3) the bone peg; (4) intermedullary graft; (5) the osteoperiosteal or the Delagénierè graft; (6) the cavernous bone graft; and (7) multiple grafts.

The Massive Grafts.—The massive onlay graft permits better mechanical fixation because of its size. The graft is removed from the internal surface of the tibia by means of an electrically driven motor saw. The crest of the tibia should not be removed as this may so weaken the shaft that fractures occur from slight violence. The graft should include, from without inward, the periosteum, the cortex, and

the endosteum. The massive graft of sufficient width, length, and thickness is mechanically united to the external surfaces of the fragments which have been denuded for a considerable distance. The graft may be fastened to the fragments by beef-bone screws, as devised by Henderson, or by autogenous bone nails. Complete internal fixation not only secures stability, but also induces osteogenesis.

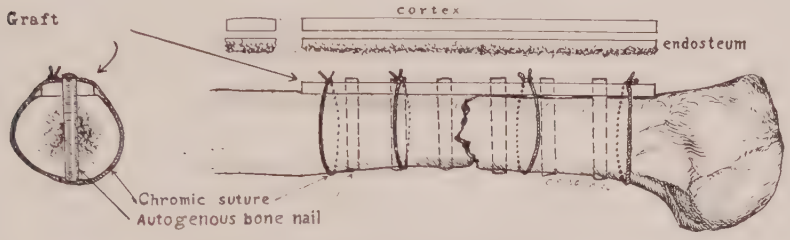


Fig. 320.—Technic of onlay bone graft.

The Inlay Graft.—The inlay graft is a transplant including all layers of the bone, periosteum, cortex, cancellous bone, and endosteum. The graft is accurately measured to conform to the dimensions of the site to which it is to be transferred and is removed with an electrically operated circular saw. Albee recommends the use of the twin saw having two parallel blades. The section of bone from the fragments as

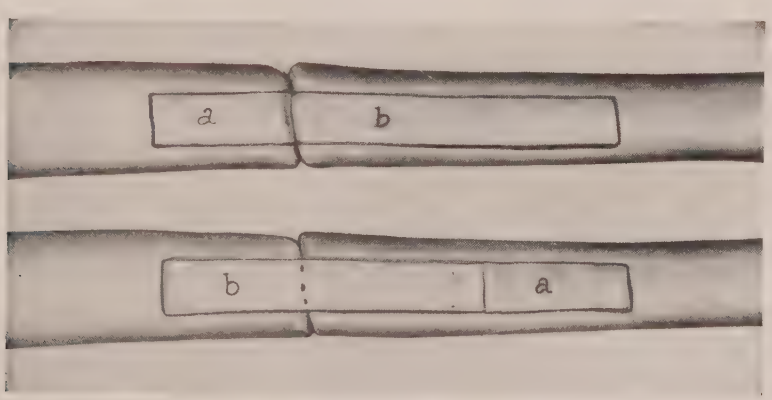


Fig. 321.—Technic of sliding inlay graft.

well as the graft itself, is removed with the saw; the blades being the same distance apart in each case, ensures an accurate coaptation of the transplant to the graft bed. Close approximation of the corresponding layers of the graft to those of the bone fragments is obtained, which is believed, by Albee, to be of value in the stimulation of bone production. The sliding graft is a modification of the inlay graft. The frag-

ments are aligned end-to-end and a section removed from both fragments with the motor saw, using the twin blades. One segment, usually that in the proximal fragment, is made longer than the other. Both segments are removed and replaced in the slot in the bone in the reverse position, the long fragment crossing the point of fracture. The graft is retained in position by bone nails or absorbable sutures passed through drill holes in the fragments.

The Bone Peg.—The bone peg may be large or small, but is removed in the same manner as the massive graft. It is modeled to the size and shape desired by bone-cutting forceps and file or by the attachment on the motor saw for making dowel pins. Bone pegs are used as nails for holding two or more fragments together, for example, fractures of the neck of the femur, oblique fractures of the long bones, or the fixation of a graft to the bone fragments. The peg may also be placed across the line of fracture, as an intermedullary graft. This type of graft can not be inserted a sufficient length into both fragments to give satisfactory mechanical fixation, as it is usually not possible to separate the fragments. It also has the disadvantage of blocking the medullary canal, and may actually inhibit the production of callus from the endosteum. The graft has, therefore, been practically discarded in the treatment of ununited fractures.

The Osteoperiosteal Graft.—The osteoperiosteal or Delagénierè graft is a flexible transplant composed of periosteum and numerous flakes of bone, and can, therefore, be made to conform to irregular surfaces, and is rich in osteogenetic properties. The technic of securing the osteoperiosteal graft is as follows: Using a curved or straight incision, the inner flattened surface of the tibia is exposed, and the skin edges of the wound are retracted. The skin and subcutaneous tissue are dissected from the tibia, leaving as much overlying soft tissue as possible attached to the periosteum. The periosteum is incised, outlining a rectangular area slightly larger than the dimensions of the graft desired, including a margin of about $\frac{1}{8}$ inch of soft tissue surrounding the graft. The outline of the graft is defined, by shallow incisions, on the surface of the bone with a chisel directed at right angles to the bone. The graft is then raised by elevating a series of bone particles from the cortex of the bone with the chisel, care being taken not to separate the particles from the periosteum. As the graft is chiseled free it curls upon itself like a shaving of wood, and when free must be straightened out before it can be transplanted.

The Cavernous Bone Graft.—Cavernous or spongy bone transplants are grafts of spongy bone secured from the extremities of the long bones,

as the femur or the tibia. Spongy bone may be secured also from the endosteum lining the medullary canal of the long bones. It is rich in bone-forming elements, and being plastic can be compressed to any shape desired. Cavernous bone is rarely used alone, but is valuable as an adjunct to the massive graft.

Multiple Grafts.—Multiple grafts consist of many small particles of bone placed in the area in which new bone formation is desired. These particles may be in the form of bone shavings removed with a sharp chisel, or of small irregular pieces of cortical or cavernous bone. They have the advantage of furnishing a comparatively large area of bare osseous surface from which bone may be produced.

The Tibia.—Fractures of the lower third of both bones of the leg are often followed by nonunion of the tibia, which is probably due to injury of the nutrient artery as it enters the tibia in this region. The fibula usually unites, but even if it does not, operative measures are carried out on the tibia alone, while the fibula is not disturbed. If union is thus secured in the tibia, the fibula will also unite, and the result is always good.

The Patella.—Ununited fractures of the patella are common, and unless the fragments are widely separated, nonunion may not seriously disturb the function of the limb. In those with wide separation, approximation of the fragments is impossible without plastic lengthening of the quadriceps tendon. Union is accomplished by a two-stage operation. The tendon is lengthened by a Z-shaped incision and the upper fragment of the patella is displaced downward, but not otherwise disturbed. After two weeks a second incision is made over the point of fracture, the fragments are denuded and approximated and an inlay graft or pin is employed to maintain them in position, and healthy spongy bone is packed about the line of fracture to promote osteogenesis.

The Femur.—In fractures of the lower third of the femur approximation of the fragments may be secured without difficulty, and the type of graft desired applied. In the upper third the problem is much more difficult, and if the operation is prolonged severe surgical shock is a frequent complication. The mortality following such operations is high, and the operation should be regarded as a very hazardous procedure. Loss of blood must be prevented by the use of a tourniquet and complete hemostasis. Fractures of the neck of the femur of the central or intracapsular type more frequently fail to unite than other fractures. Clinically, there is no stage of delayed union in central or intracapsular fractures; if approximation is not made when the fracture is recent, the fragments remain separated, and there is evidence of

nonunion at the end of six weeks. Judgment must be used in selecting the surgical procedure for each case. As a general rule, if the physical condition of the patient is good, union may be secured by a bone graft operation. The fractured surfaces are denuded and approximated; a large bone peg is removed from the tibia or fibula and driven through a drill hole in the trochanter and neck, well into the head of the femur. The after-treatment consists of prolonged immobilization similar to that for recent fractures of the neck of the femur. The bone graft is especially indicated in those under sixty years of age in whom the fracture is of less than six months' duration, but may be successful in any case in which the head and neck of the femur is well preserved and not atrophic. In those in whom a year has elapsed since the accident, or in whom the head and neck show definite and extensive osteoporosis, a surgical procedure known as the reconstruction operation of the hip may give an excellent functional result, and thus restore to activity a class of patients who, in the past, have remained hopelessly crippled.

Reconstruction Operation (Whitman).—An incision is made in the shape of a half U, beginning about 1 inch behind the anterior superior spine and extending downward and backward, crossing the femur at a point 3 inches below the apex of the trochanter. The interval between the tensor vaginae femoris and the gluteus medius muscles is exposed; the capsule is opened and the head of the femur is removed. The anterior margin of the gluteus minimus is followed to its insertion, and at this point the base of the trochanter is cut through with a wide thin chisel in an oblique direction corresponding to the angle of the neck, including all the muscular attachments and often a part of the capsule. This flap of bone and muscle is turned upward and the upper extremity of the femur, having been somewhat remodeled by cutting away the projections of the posterior intertrochanteric line, is free from any restraining tissues and is thrust completely within the acetabulum at an angle of about 155 degrees of abduction. The trochanter is then drawn downward as far as its attachments will permit, and sufficient cortex having been removed from the lateral aspect of the femur, the two bare surfaces are apposed, and the trochanter is secured in this position either by a peg or by a suture passed through the bones. The wound is closed in layers and a long plaster spica cast is applied fixing the limb in extension and abduction. When repair has sufficiently advanced, or in about six weeks the cast may be replaced by an abduction hip brace and the patient is encouraged to bear weight in order to hasten the functional adaption of the reconstructed articulation.

When weight may be borne without discomfort, the support is removed and muscular control reestablished by systematic exercise. This procedure has the advantage of a relatively short period of confinement and the results are often excellent.

The Humerus.—Fractures of the shaft of the humerus result in nonunion more frequently than fractures of other bones. The massive onlay graft is the most efficient manner of fixation and gives the best end result.

Fracture of the external condyle of the humerus causes a typical deformity of the lower extremity of the humerus and the elbow, and

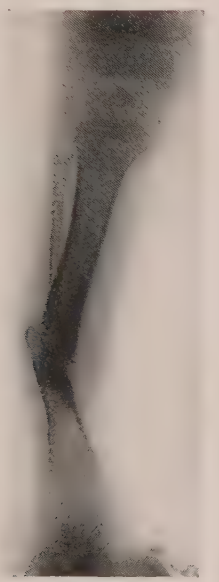


Fig. 322.—Ununited congenital fracture of tibia and fibula. Anteroposterior view.

Fig. 323.—Same as Fig. 322. Lateral view.

is often ununited. The lower fragment should be replaced and fixed by means of a bone peg and autogenous osteoperiosteal graft to reconstruct a new lower extremity for the humerus.

The Radius and Ulna.—Fractures of the radius, especially in the lower third, are more frequently ununited than fractures of the ulna. An ununited fracture of both bones of the forearm is more frequent than either the radius or ulna alone. The operative procedure is most difficult when there is nonunion of both bones. The procedure is tedious and unless it can be dispatched with precision and within reasonable limits of time, the results are often disastrous.

The Carpal and Metacarpal Bones.—Fractures of the carpal bones

often remain ununited and cause persistent pain; particularly is this true of the scaphoid. The treatment is operative excision of the entire bone.

Ununited fractures in children are of exceedingly rare occurrence and are most resistant to treatment. The constitutional treatment is the same as of nonunion in adults, which entails a careful search for the etiologic factor and its eradication, if possible. Many ununited fractures are probably due to congenital deficiency in bone production and are perhaps closely related to congenital fracture. The operative

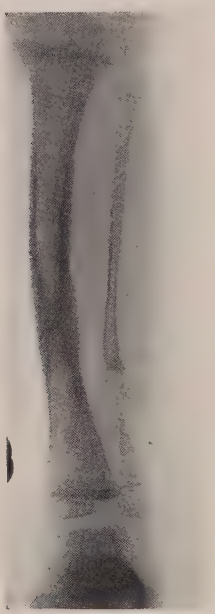


Fig. 324.—Solid union of ununited congenital fracture of tibia and fibula after homogeneous bone graft from mother. Anteroposterior view.

Fig. 325.—Same as Fig. 324. Lateral view.

treatment is by autogenous bone grafts. The author prefers the massive graft with the transference of small particles of spongy bone about the affected area, as spongy bone has been found to possess a marked reproductive quality. The Delagénierè graft is also employed in the treatment of ununited fractures and consists of a wide strip of the periosteum removed from the tibia, together with small flakes of the cortex. Bone grafts are also used to fill defects where continuity has been lost. Firm attachment at both ends is necessary, and when possible, throughout the entire length of the graft.

Congenital fractures must be differentiated from birth fractures. Birth fractures are those which occur from trauma during childbirth, and are the same as any other type of fracture. Congenital fractures are due to developmental errors, and there is a definite embryological defect which must be combated in addition to the fracture. Congenital fractures are of rare occurrence and resistant to every attempt at treatment. There are three types: (1) Those which are loose and flail at birth; (2) those in which there is feeble malunion and which are later refractured by some slight injury; (3) those in which there is feeble union in good position, but the bone is weak at the point of union and refractured later in childhood. The second and third types respond better to operative measures, whereas the first type is considered by many as hopeless. Every form of bone graft has been employed in the treatment of congenital fractures. The author has been successful in a case of the first type, in which a homogeneous graft from the mother was employed. Bone grafts in children are not satisfactory, as a rule, until the child has reached the age of eight years, as the quality of the bone is such that osteogenesis can not be expected. In late childhood and about puberty, the bone graft is very effective, as in young adults. Bone grafts may be of various sizes, but the author prefers the massive graft, as he regards fixation and osteogenesis as the essential elements. The Delagenière graft is more effective when used in conjunction with a massive graft than when used alone, and is often a valuable adjunct. Also, when possible,

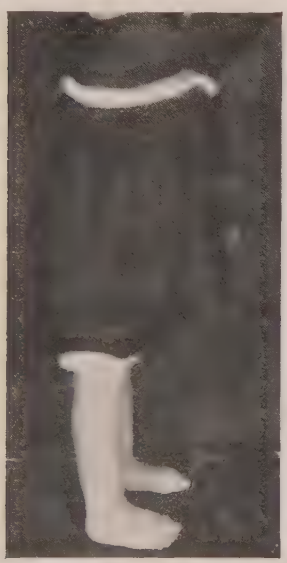


Fig. 326.—Photograph of child (Figs. 322–325) showing contour of right leg after operation.

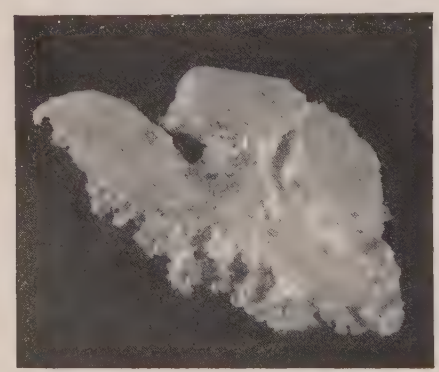


Fig. 327.—Cross-section of graft applied to femur showing osseous union.

small particles of spongy bone are placed about the graft. Foreign materials, such as silver wire or bone plates, are not usually advisable in children; autogenous nails made from the graft are to be preferred.

MALUNITED FRACTURES

Malunited fractures are those which have become united in an abnormal position; vicious union causes deformity and often serious impairment in function. Function is impaired mechanically in various ways; there may be blocking of a neighboring joint by the projection of overlapping fragments; angulation of the fragments may interfere with proper balance; or overriding of the fragments may induce material shortening. Malunion is caused by failure of proper anatomical reduction, or by bending of the immature callus before consolidation is complete.

The Metatarsal Bones.—Malunion of the shafts of the metatarsal bones may cause irregular masses on the sole of the foot which give pain in walking. This would be avoided if the fracture were treated originally by elevating the region with pads. The treatment, after union has occurred, consists of refracturing the bone through a dorsal incision, removing the exuberant callus and projecting particles of bone, reducing the fragments, and then elevating the shafts as in the treatment of recent fractures of this region.

The Tarsal Bones.—Malunion in fractures of the tarsal bones often induces a rigid flatfoot or pes planus. Such a condition may require forcible correction or tarsectomy to reconstruct the arch, after which a plaster cast is applied with the arch elevated to the normal position until union is solid; an arch support must be worn continuously until there is no chance of recurrence of deformity. Malunion in fractures of the os calcis is so common as to be almost the usual result. The foot is in a position of planus, there is a bulging under the external malleolus from callus formation and the normal inward curve of the os calcis is lost. Pain is often continuous from postural imbalance and from callus formation below the external malleolus and in the subastragalar joint. Lateral movements of the foot are usually completely lost. The roentgenogram will demonstrate the typical lesion of an ancient and malunited fracture of the os calcis. The treatment is entirely surgical, although proper shoes and arch supports may give partial relief. The operation consists of the removal of the exuberant callus about the external malleolus, which, at times, invades the ankle joint. Fusion of the calcaneo-astragaloid joint increases the percentage of good results, and fusion of the other tarsal joints,

the astragaloscaphoid and calcaneocuboid may be rarely indicated. Malunion of the astragalus usually causes varus of the foot, and often equinus, a traumatic equinovarus. Persistent pain with total disability is common when the fracture involves the head or neck of the astragalus. The treatment consists of removal of the head with arthrodesis of the astragaloscaphoid and calcaneocuboid joints; when the body of the astragalus is fractured, the entire astragalus should be excised.

The Tibia and Fibula.—An unreduced Pott's fracture commonly causes disability of the ankle joint. There is marked valgus of the foot, often backward dislocation of the ankle, prominence of the internal malleolus, and contracture of the tendo achillis. The roentgenogram will demonstrate that the line of articulation between the

Fig. 328.—Malunited Pott's fracture. Anteroposterior view.

Fig. 329.—Same as Fig. 328. Lateral view.

tibia and astragalus slopes obliquely downward and inward; whereas, normally, it is transverse. Pain is often continuous and endurance decreased so that standing or walking any distance may be impossible. In the mild cases simple leather arch supports with ankle corsets may give relief; in others, operative measures are indicated, marked eversion deformity should always be corrected by an osteotomy just above the malleoli extending through both bones. This is best accomplished by two incisions, one over the lower extremity of the fibula and one over the lower extremity of the tibia. In those with extreme eversion of the foot, a wedge of bone must be removed from the tibia. Care must be taken that the joint line, demonstrated by the roentgenogram, is transverse. The tendo achillis is frequently contracted and must be elongated through a separate incision. A plaster cast is employed to hold the foot in slight inversion, and is changed at the end of three

weeks. After such correction, there is usually complete relief of symptoms.

The ankle joint may be restricted in dorsiflexion by fracture of the lower extremity of the tibia and downward displacement of the lower or distal fragment. The removal of the fragment will give free motion, provided there is no complication by contracture of the tendo achillis. When this occurs, the structure should be elongated by the Z-shaped plastic method. In all fractures involving the ankle joint, a traumatic arthritis may persist. In those who do not respond to conservative measures, and who, for economic reasons or choice, do not desire to take the chance of two operations, the ankle joint may be

Fig. 330.—Malunited Pott's fracture after operative correction. Anteroposterior view.

Fig. 331.—Same as Fig. 330. Lateral view.

fused. Malunited fractures of the shafts of the tibia and fibula are usually curved backward or laterally. Function is seldom disturbed sufficiently after fractures of the leg to require operative methods for relief. However, osteotomies for restoration of the anatomical alignment are rarely necessary. Fractures of the tuberosities of the tibia may result in malunion, causing severe functional disturbances of the knee joint. Correction may, at times, be secured by refracture with elevation, depression or rotation of the fragment until the anatomical contour of the joint surface is restored; if great irregularity persists an arthroplasty or a fusion operation of the knee may be indicated.

The Femur.—Malunion of fractures of the condyles of the femur is treated in a manner similar to vicious union of the tuberosities

of the tibia. Malunion in the shaft of the femur may induce rotary deformities with bowing from angulation and torsion, or there may

Fig. 332.—Malunited fracture of tibia.

Fig. 333.—Malunited fracture of femur. Anteroposterior view.

Fig. 334.—Same as Fig. 333. Lateral view.

be in addition overlapping of the fragments with decrease in length. Such cases may be treated by a simple transverse osteotomy with the restoration of anatomical alignment, or the site of the fracture may

be rebroken, after which continuous strong traction may decrease the amount of shortening or restore the normal length. In the hip joint motion may be impeded and painful, due to fractures comminuting the head of the femur or the acetabulum. The only treatment is surgical, with removal of the irregularities. If there is extensive incongruity, arthroplasty offers the best chance of restoring function. The results of such procedures depend upon the proportionate size of the remaining head and neck of the femur. If there has been extensive loss of substance, a normal joint cannot be restored, but marked

Fig. 335.—Malunited fracture of femur.

Fig. 336.—Same as Fig. 335. After correction by osteotomy.

improvement in function and endurance may be expected. In some instances, the results are the same as those secured by reconstruction operations for fracture of the neck of the femur; in fact, the procedure, if there has been extensive destruction of the neck, may be the same. Rarely fusion of the hip joint may be indicated, when there is persistent pain, especially in those past middle age.

The Humerus.—The elbow is more frequently affected by extra-articular formations of bone than any other joint. One of the most common causes of limited motion is the unreduced supracondylar

fracture, with backward displacement of the lower fragment. The elbow is blocked by the projecting and overriding upper fragment, often associated with cubitus varus or loss of the carrying angle. The obstruction to flexion may often be corrected by a very simple operative procedure. A lateral incision is made exposing the lower extremity of the upper fragment. The overhanging portion is trimmed smoothly away until there is no block to flexion, and the wound is closed. Restoration of complete function should be accomplished in a few months; active use may be instituted as soon as the wound has healed. If there is loss of the carrying angle or a marked torsion of the elbow, a refracture may be required, but in most instances, the restoration of

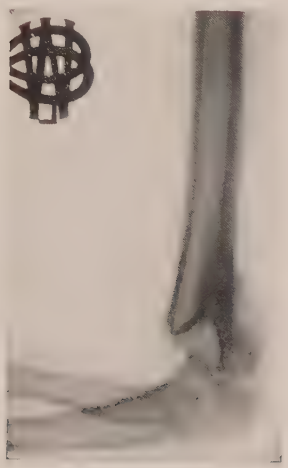


Fig. 337.—Malunited supracondylar fracture with impingement of lower end of shaft of humerus on coronoid process of ulna.

Fig. 338.—Same as Fig. 337. After surgical removal of mass of bone.

flexion and extension by this simple procedure is quite sufficient. In malunited T fractures and comminuted fractures of the elbow, there is usually such impairment of joint function and such irregular union that a reconstructive operation of the entire joint is indicated, as arthroplasty of the elbow. Extension of the elbow is not uncommonly blocked by the formation of a mass of bone in the olecranon fossa of the humerus, fractures of the capitellum or head of the radius, with bone particles in the joint. The obvious treatment is the removal of the offending mass. If there is extensive irregularity arthroplasty may be indicated.

The Radius and Ulna.—Rotation of the forearm may be limited by comminuted fractures of the head and neck of the radius, when

the head must be excised well below the neck. This will usually increase motion, but rarely restore normal function. Synostoses uniting the upper extremity of the ulna and radius are not uncommon and require complete excision of the bone mass. A portion of normal bone from the ulna and radius should also be removed, after which a pedicle flap of fascia or free transplant of fascia lata must be interposed. Localized myositis ossificans of the brachialis anticus muscle is quite common and may block motion in flexion and extension. No treatment is indicated until the newly formed bone has become completely organized and encapsulated, which usually requires at least six months. In many instances, the bony mass will eventually be absorbed. However, if, instead of absorption, there is complete organization into

Fig. 339.—Roentgenogram showing malunited Colles' fracture. Anteroposterior view.

Fig. 340.—Same as Fig. 339. Lateral view.

dense bone, excision should be made through the external lateral approach. Normal motion will gradually be restored in about six months to a year. Convalescence is more prolonged in affections and injuries of the elbow than in any other joint. Fracture of the shaft of the ulna just below the coronoid process, associated with dislocation of the head of the radius, may seriously impair function. This type is mentioned because it so often deludes the physician and a poor result is unsuspectingly secured. Motion of the elbow may be markedly limited in both flexion and extension. The treatment is refracture and restoration of anatomical alignment with reduction of the dislocation.

Compensation following malunited fractures of the shafts of both

bones of the forearm is usually obtained by motion in the joints of the upper extremity, so that operative correction is rarely indicated. However, there may be such gross angulation that an osteotomy or other plastic procedures may be required to restore the anatomical alignment. One of the most common fractures in which malunion is observed is the unreduced Colles' fracture. The resultant silver-fork deformity may be reduced by removing a small wedge from the radius with the base anteriorly. The bone is then easily broken through and the backward displacement reduced so that the articular cavity of the radius faces downward and slightly forward. This will leave a wedge-shaped space above into which the wedge of bone excised from the anterior aspect is placed, thus retaining the articular surfaces in

Fig. 341.—Malunited Colles' fracture after operative correction. Anteroposterior view.

Fig. 342.—Same as Fig. 341. Lateral view.

position. A second incision is made over the lower extremity of the ulna, which is usually relatively longer from shortening of the radius. The protruding portion is excised and the head of the ulna remodeled; this removal balances the articulation and prevents mesial blocking. At the same time the normal contour will be restored, which undoubtedly has a salutary effect on the patient. The wrist is placed in a plaster cast, palmar flexed, with the fingers free.

The Carpal and Metacarpal Bones.—Malunion of the carpal bones seldom occurs, but when present, causes symptoms of pain, and excision is the only treatment. Malunion in fractures of the metacarpal bones and phalanges may be treated along the same principles as

malunited fractures elsewhere. As in all fractures, apparatus must often be continued over a long period of time and should not be discarded until there is complete organization of the callus, and all possibility of recurrence of deformity has passed. Physiotherapy is indi-

Fig. 343.—Malunited Colles' fracture.

Fig. 344.—Same as Fig. 343. After correction.

cated, especially in those malunited fractures in the vicinity of joints. Efficient treatment will materially reduce the incidence of both delayed and ununited fractures.

BIBLIOGRAPHY

Albee, F. H.: Bone Graft Surgery, Philadelphia, W. B. Saunders Co., 1919, p. 572.

Barton, Rhea: Medical Examiner, Philadelphia, 1838, p. 365.

Delagénierè, M. H.: Greffes Osteoperiostiques, Jour. de Chir., 17: 305, 1921.

Funsten, Robert V.: A New Splint for Fracture of the Clavicle, Jour. Amer. Med. Assoc., 91: 794, 1928.

Henderson, M. S.: Nonunion in Fractures: The Massive Bone Graft, Jour. Amer. Med. Assoc., 81: 463, 1923.

Howland, J., and Kramer, B.: Calcium Phosphorus in Serum in Relation to Rickets, Amer. Jour. Dis. Child., 22: 105, 1921.

Whitman, Royal: The Reconstruction Operation for Arthritis Deformans of the Hip Joint, Ann. Surg., 80: 779–785, 1924.

CHAPTER XII

CONSTITUTIONAL AFFECTIONS OF BONE

ACUTE INFECTIOUS OSTEOMYELITIS

Acute pyogenic infection of bone is caused by the invasion of the bone by pyogenic bacteria; an acute inflammatory process is induced which is known as acute infectious osteomyelitis. The term "periostitis" denotes an inflammatory reaction confined to the periosteum, but the acute form is of such rare occurrence as to be dismissed with mere mention. Osteitis signifies an inflammation of the osseous tissue and osteomyelitis an affection involving all the structures of the bone, the periosteum, cortex, cancellous bone, endosteum, and the central canal. In the literal meaning, an inflammatory process in bone from any cause is osteomyelitis, but for convenience in this discussion, all prefixes will be omitted and the term "osteomyelitis" employed to signify an inflammatory process induced by the invasion of pyogenic organisms alone.

Etiology.—The staphylococcus and streptococcus are the usual causative agents. The *Staphylococcus aureus* is by far the more frequent etiologic factor. The infection may be derived from distant foci, as the tonsils, middle ear, furuncle of the skin, paronychia, etc., and is conveyed to the bone by the blood stream. Following typhoid fever, infection of one or more bones may occur, and upon culture, the *Bacillus typhosus* may be demonstrated. Osteomyelitis may also be caused by direct infection from without, as gunshot wounds and compound fractures, but such cases present very different surgical problems. A history of preceding injury is so common as to be recognized as a definite predisposing factor, the trauma lowering the local resistance of the part. Debility following acute infectious and contagious diseases may also be considered a predisposing cause. Osteomyelitis is of more frequent occurrence than any other destructive processes in bone and is more prevalent during the period of rapid osseous growth. The arrangement of the blood vessels in the metaphyses of the long bones is a factor in the high incidence of the disease during the growth period. The arrangement of the vessels of the primary areolae into loops among the cartilage cells leads to a slowing of the circulation,

favors the lodgment of bacterial emboli, and determines the location and development of the inflammatory focus. Children are affected more frequently than adults, and boys more frequently than girls. Any part of the skeleton may be involved, but the infection more often lodges in a long bone adjacent to the epiphyseal cartilage. The order of frequency in which the bones are affected is the tibia, femur, humerus, and radius. No bone is exempt and osteomyelitis may also occur primarily or secondarily in the flat or spongy bones.

Pathology.—The process may be local or diffuse, but is more frequently local. Localized osteomyelitis is confined more often to one bone, but may extend through the epiphysis and joint cavity into the adjacent bones. Diffuse or generalized osteomyelitis may begin in one bone, but the infection is rapidly disseminated into many bones.

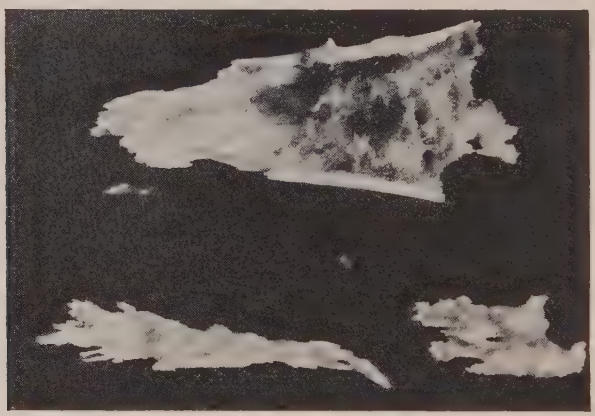


Fig. 345.—Sequestra removed at operation from chronic osteomyelitis of tibia.

The infection begins usually in the medullary canal, near the epiphysis, inducing an intense hyperemia, which is followed by suppuration within the bone. Intra-osseous tension is increased and after several days the pus may be forced through the haversian canals and by way of the metaphysial region to the periosteum. This membrane is raised from the cortex and separated more or less rapidly from the bone depending upon the virulence of the infecting organism. The periosteum in turn may be ruptured with an extravasation of pus into the surrounding tissues, inducing a diffuse cellulitis. Blood-stream infection is not uncommon and blood cultures are positive in a high percentage of cases. Bone is slow to respond to irritation, so that the local reaction may not be apparent in the roentgenogram for a considerable time. The inner surface of the periosteum proliferates, forming a cylin-

drical mass of dense, hard, eburnated bone which surrounds the affected area. The new bone formation is known as the involucrum, and is pierced by irregular fenestra through which the purulent material is discharged. Coincidentally with the evolution of the infection, the original bone dies en masse or in disseminated areas. The shaft of the bone may be destroyed by the toxic action of the pus or by the interference with the circulation by plugging of the vessels by the exudate and the separation of the periosteum. The devitalized bone is known as a sequestrum. The sequestra gradually become detached from the living bone, remain loose within the involucrum, and are

Fig. 346.—Acute osteomyelitis of femur, early stage with slight structural change.

Fig. 347.—Same as Fig. 346, four months later, showing extensive proliferation and destruction.

surrounded by pus, necrotic detritus, and atrophic living bone. After the pus has been discharged into the surrounding tissues, the abscess ruptures externally and numerous sinuses are formed which lead from the interior of the bone to the skin. The sinuses are tortuous and are lined by low-grade dense scar tissue. The evolution of the entire process requires from three to six months, after which it persists indefinitely, purulent discharge flowing through the fenestra in the involucrum and through the sinuses in the soft tissues to the surface of the skin. This condition may continue for months, years, or even

throughout life. The sequestra may be extruded, with closure of the sinuses; rarely, the sequestra may be encapsulated by healthy granulation tissue, with closure of the sinuses. Retained sequestra or incorporated infectious material may remain in the bone or soft tissues indefinitely, but are prone to become active at some future time with relighting of the acute inflammatory process. The involucrum, except in very early childhood, is replaced by dense eburnated bone of inferior quality, which bears the same relation to normal bone as dense scar tissue does to normal soft tissue. The soft tissues and skin surrounding the affected bone are involved in the inflammatory process and may become adherent to the bone over large areas.

The process in cancellous or spongy bone is similar, except that the spread is more rapid, as the pus is not encased within nonresistant walls. The bone rarely dies en masse, but multiple sequestra are formed which are surrounded by atrophic and proliferating bone. The reaction is more marked throughout the interior of the bone, but the periosteum does not proliferate to the same degree as it does in infection of the long bones. Large cavities may be formed within the bone, more frequently in the upper extremity of the tibia, and are known as Brodie's abscesses. Sequestra and cavities filled with pus may be obscured by the involucrum. The adjacent joints may contain increased fluid which may be only serous in character, or the exudate may be purulent from extension of the infection. In young children an almost normal bone may be restored, while in older children and adults there is more or less substitution by dense sclerotic bone.

Symptoms.—The symptoms and clinical manifestations of osteomyelitis may be divided into three stages: (1) acute, (2) subacute or chronic, and (3) stage of residual impairment.

Acute Stage.—The onset of the acute stage is sudden, often with chill and in young children convulsions are not uncommon. There is evidence of a septic infection; the temperature is high, ranging from 103 to 106 F. The pulse rate is rapid and there may be stupor or delirium. In virulent infections, death may ensue before local symptoms are evident, but never before they may be elicited by a careful examination. The localized pain of an intense throbbing and boring character is constant, and is typical of increased intra-osseous pressure. Slight, if any, swelling of the soft tissues is present at the onset and is seldom observed until the purulent exudate reaches the periosteum. When the pus breaks through the periosteum, which may require several days, the pain subsides and the severity of the constitutional symptoms diminishes. Abscesses develop in the soft tissues causing

further extension of the infection. The blood examination shows a high leukocytosis and marked increase in the polymorphonuclear leukocytes. At the time of the onset and often as long as three weeks thereafter, there may be no apparent reaction in the bone that can be demonstrated by the roentgenogram; consequently, the roentgenogram is of diagnostic value only in the early stage by excluding other pathologic processes. The first manifestation, proliferation of the periosteum about the infected area, is observed from one to four weeks

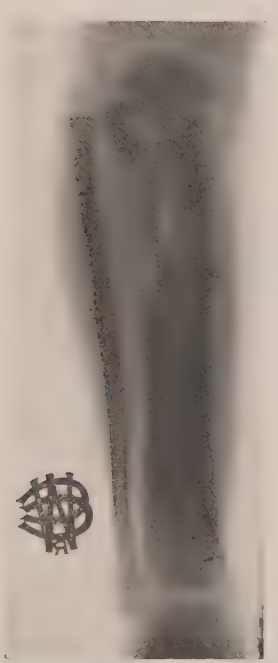


Fig. 348.—Chronic osteomyelitis of tibia with cavity formation, denoted by dark areas of condensed bone surrounded by proliferation and formation of involucrum about sequestra. Anteroposterior view.

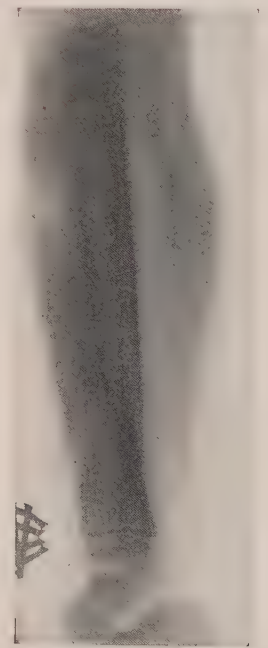


Fig. 349.—Same as Fig. 348. Lateral view.

after the onset. Unless interrupted by early surgical measures, the duration of the acute stage is from four to six weeks, but may be continued indefinitely. The constitutional symptoms subside with the evacuation of the pus, and the subacute or chronic stage is reached.

Subacute or Chronic Stage.—When an early diagnosis has been made and efficient surgical measures instituted, the chronic stage is less prolonged. Frequently, however, the diagnosis is not made until many weeks have elapsed. During the subacute stage the intensity of the

constitutional symptoms is lessened, the general condition improved, although the temperature may remain slightly elevated. One or more sinuses at various points continue to drain; on palpation there is swelling and induration of the soft tissues, hypertrophy of the bone, and the affected area is tender to pressure. Unless deformity has been prevented, the adjacent joints may be contracted in malposition. The leukocyte count remains high as long as there is constitutional evidence of infection. The roentgenogram at this time is of great value and shows destruction with loss of density in the affected portion of the

Fig. 350.—Osteomyelitis eleven months after radical operation with dense new bone formation. Anteroposterior view.

Fig. 351.—Same as Fig. 350. Lateral view.

bone. The periosteum is separated from the shaft of the bone and the formation of the involucrum is apparent. The roentgenogram is characteristic in the later stages when the sequestra have separated. The sequestrum is dense and stands out in marked contrast to the surrounding necrotic bone.

Residual Stage.—The stage of residual impairment is observed after the sinuses have healed. On palpation the bone is usually hypertrophic, being often twice the normal size. The skin may be adherent over a large area, especially when such superficial bones as the tibia

are involved. Pain is often experienced in cold weather or after fatigue, though the individual may not be seriously incapacitated, unless contractures of the soft tissues or destruction of bones and joints have induced deformity or arrested function. Extensive destruction with atrophy of osseous structure is at times apparent, and dead bone, or sequestra, when present, retain the same density as at the time of death, and consequently stand out in marked contrast to the surrounding atrophic bone. The dense involucrum of the chronic stage is observed surrounding necrotic and atrophic bone and sequestra. Massive hypertrophy and often cavities are seen at this stage. The bone may become so dense and hypertrophic that active processes, sequestra, or cavities are obscured. When the infection has involved the epiphyses the growth of the bone may be influenced. The length of the long bones, especially the tibia and femur, may be increased so that the affected leg is longer than the normal leg; the growth may be arrested, causing pronounced shortening, or the growth may be irregular, resulting in abnormal relations and deformity of the adjacent joints.

Fig. 352.—Chronic osteomyelitis of tibia with multiple draining sinuses.

Fig. 353.—Increase in length of tibia caused by irritation of the epiphyses following chronic osteomyelitis.

Diagnosis.—Early diagnosis is essential for conservation of bone and often for saving the life of the patient. The correct diagnosis in

the acute stage can be made if the following symptoms and local manifestations are observed: sudden onset, high fever, generalized sepsis, high leukocytosis, and intra-osseous pain without swelling. Pain from increased intra-osseous tension is intense, boring in character, and is enhanced by firm continuous pressure. The suspected area is palpated to locate the tender points; firm pressure is made over this area with the index finger. If the intra-osseous pressure is increased from any cause, intense pain will be experienced and the patient will scream with agony. The roentgen ray at the onset is of no positive value in diagnosis.

In the subacute or chronic stage, the diagnosis can be made by the history, the local manifestations, and the roentgenogram, any one of which is pathognomonic. The erroneous diagnosis of bone tuberculosis is made frequently; this common mistake could be avoided by remembering that tuberculosis and osteomyelitis begin near the end of the bone, but tuberculosis almost invariably travels in the direction of the joint which it invades, while osteomyelitis travels in the opposite direction down the shaft. When osteomyelitis invades a joint, the shaft is also involved in a hypertrophic process, whereas, in tuberculosis, there is atrophy and the area of destruction is confined to the vicinity of the joint and does not involve the shaft of the bone for an appreciable distance. The onset, clinical course, and roentgenological manifestations of osteomyelitis and tuberculosis are also obviously different. In tuberculosis of the bone with secondary purulent infection, the differentiation is more difficult, but can be distinguished by the history of a low-grade infection prior to the acute symptoms. Distinction must also be made between endothelioma of bone, the so-called Ewing tumor, and chronic osteomyelitis. The differential diagnosis may be very difficult, especially when the patient is first seen several months after the onset or when a secondary infection has developed in a Ewing tumor. The pain, swelling and roentgenological manifestations may be almost identical in the two conditions; the elevation of temperature is usually not so great in endothelioma as in osteomyelitis and the onset is more gradual without the acute initial symptoms of sepsis. Ewing's tumor is also characterized by intermittent attacks in which pain and fever are present. The diagnosis in the stage of residual impairment is readily made by the previous history and the roentgenological examination. If there is no history available, differentiation must also be made from bone syphilis and osteomyelitis of Garré.

Prognosis.—In the acute stage of osteomyelitis of the long bones

the prognosis depends entirely upon the diagnostic acumen of the attending physician and the immediate relief of intra-osseous tension by drainage of the affected area. Relief of pressure lessens the amount of osseous destruction. In virulent infections, death may ensue from sepsis, regardless of the treatment, but in a high percentage recovery with restoration to normal may be expected if the proper procedures are efficiently carried out. The prognosis is also influenced by the location of the process; virulent infections with extensive involvement of the spinal vertebrae are usually fatal. During the chronic stage the results also depend upon the efficiency of the surgical procedures. When the sequestra and necrotic detritus can be removed and adequate drainage established, complete healing may be expected. In certain inaccessible locations, as the lower extremity of the femur and the pelvis, where extraction of sequestra with efficient drainage is often impossible, the process may continue indefinitely. The stage of residual impairment is characterized by the formation of dense eburnated bone with a deficient blood supply. In consequence, symptoms of pain in cold weather or after fatigue may persist throughout the life of the individual. The younger the child at the time of the original infection, the nearer normal in structure will be the substituted bone. Abscesses or local exacerbations, with or without trauma, may occur many years later, but if there are no retained sequestra or large cavities, the process usually subsides.

Treatment.—The treatment of acute osteomyelitis is surgical drainage of the infected bone. The operation prevents the generalized spread of the infection, limits the formation of sequestra, and prevents the development of deformities. The diagnosis should be made in the acute stage within the first few days. The point of greatest tenderness is localized by the test for intra-osseous pressure; an incision is made over this point, down to and extending through the periosteum. If there is an accumulation of pus beneath the periosteum, drainage of this abscess alone may be sufficient, and is thought by some surgeons to be the safest procedure. If pus is not encountered beneath the periosteum, two or more holes are made with a bone drill into the medullary canal; one hole is not sufficient for drainage, as the principle of siphonage is involved. If pus was not encountered beneath the periosteum, it may flow from the drill holes. A small trap-door may be made with mallet and chisel, instead of the drill holes, or drainage of the affected area can be accomplished with an ordinary gimlet or drill of any kind. A small wire nail and hammer may be employed, but great force should not be used. The most common error is to

make too shallow an incision and fail to reach the periosteum. The incision should be left open; tubes and gauze packing may be placed in the wound for drainage, or tubes may be inserted for irrigation of the wound with Dakin's solution. Deformity should be prevented when the process is in the vicinity of a joint, or when there is the slightest evidence of muscle contracture. Apparatus to retain the limb in the most useful position should be applied and continued until the inflammatory process subsides; at the slightest sign of recurrence of deformity or malposition the apparatus should be reapplied.

In subacute or chronic osteomyelitis the treatment requires great skill and judgment. Insult is often added to injury by repeated curetage when time alone would suffice to effect a cure. When there are draining sinuses, but no large sequestra, tissue may often be conserved by a course of watchful waiting. When sequestra are apparent, they should be extracted, the necrotic detritus removed, and cavities obliterated. Correction of existing deformities by apparatus or operation is indicated in the stage of residual deformity. Mild symptoms as slight pain in cold weather and fatigue require no treatment except rest. When the attenuated infection is relighted, there is intense, throbbing pain, elevation of temperature, and leukocytosis. Considerable skill may be required to locate an abscess within a bone cavity by the roentgenogram, as the eburnated bone may obscure the cavity. Frequently, cavities containing infectious material are filled with dense fibrous tissue, and may remain quiescent for life, thus causing great difficulty in distinguishing a latent from an active process. Areas of scar tissue adherent to bone frequently ulcerate after slight trauma and predispose to superficial infection. Large scars should be excised and the bone covered with freely movable soft tissue and skin. Plastic procedures are described in the section on affections of the soft tissues.

Direct or secondary infection in compound fractures and gunshot wounds frequently results in osteomyelitis. The symptoms differ from those observed in primary hematogenous infections; the medullary canal is open and intra-osseous pressure is not increased. The treatment consists of efficient drainage and débridement when necessary.

Orr Technic.—The method described by Orr for the treatment of the acute and chronic forms of osteomyelitis depends upon three principles: (1) Adequate drainage of the infected focus; (2) packing of the wound with an aseptic dressing; (3) immobilization in a plaster-of-paris cast. The drainage of the infected area is similar to the routine method of drainage used in osteomyelitis, but larger incisions are usually necessary. In the chronic cases sequestra are removed and the

cavities thoroughly exposed. An aseptic dressing of considerable size is placed into and about the wound and is not disturbed for a number of weeks or until healing is thoroughly established. An incision having been made into the affected area, the wound and surrounding skin are carefully dried, painted with tincture of iodine, and the entire wound packed open with sterile vaselin gauze strips. No drainage tubes or sutures are inserted. A plaster cast is applied of sufficient size to immobilize the part completely. The wound is undisturbed for three to six weeks, unless there is an unusual rise in temperature, or the patient complains of excessive pain. After several weeks the cast is changed, the wound dressed, and repacked with vaselin gauze. Immobilization should not be discontinued until healing is complete.

TUBERCULOSIS OF THE BONES

Tuberculosis in the shaft of the bone occurs very rarely, although the diagnosis of tuberculosis is frequently made erroneously when the process is in reality an infectious osteomyelitis. The pathology is identical to that of tuberculosis of the joints, except that the disease involves the diaphysis of the bone instead of being confined to the cancellous extremity. The process begins with local pain, which may be of a boring nature, but is rarely so severe as in acute infectious osteomyelitis. The symptoms of intra-osseous pressure may be present for months without swelling. When the infection reaches the periosteal surface of the bone, there is induration from reaction on the part of the soft tissues. The temperature may be normal or slightly elevated in the afternoons, usually ranging from 99 to 100 F. The progress of the disease is slow and insidious. The roentgenogram shows destruction of bone with atrophy; a large cavity often forms, which may remain encased within the bone or break through to the surface and discharge tuberculous detritus into the surrounding soft tissues. If treatment is instituted early, the prognosis is favorable. When a local focus may be excised, operative measures should be employed. Heliotherapy is indicated, since the local manifestation is always an evidence of a general systemic tuberculous infection of the patient.

SYPHILIS OF THE BONES

Osseous lesions are present in a very large percentage of those affected with syphilis. The bone manifestations occur only in the tertiary stage; any bone in the body may be involved, but the tibia is affected most frequently. In children, syphilis is usually congenital. The term "hereditary syphilis" has been discarded, as the disease is

not derived through the germ plasm, but is acquired in utero, probably from the blood of the mother. In congenital syphilis, bone changes may be present in the fetus or at birth; in acquired syphilis they occur late in those cases which have been untreated or inefficiently treated. The prevalence of bone syphilis depends upon the morality and ignor-

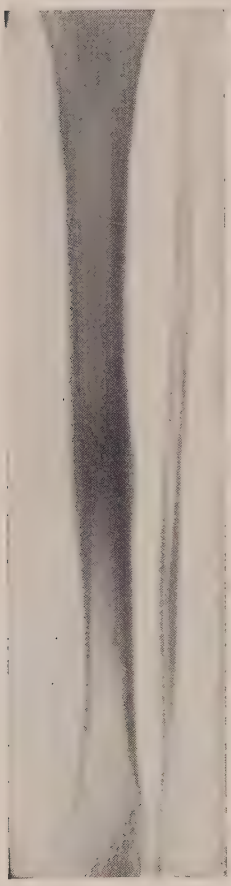


Fig. 354.—Syphilitic periostitis of tibia, with longitudinal deposition of new bone in layers. Anteroposterior view.

Fig. 355.—Same as Fig. 354. Lateral view.

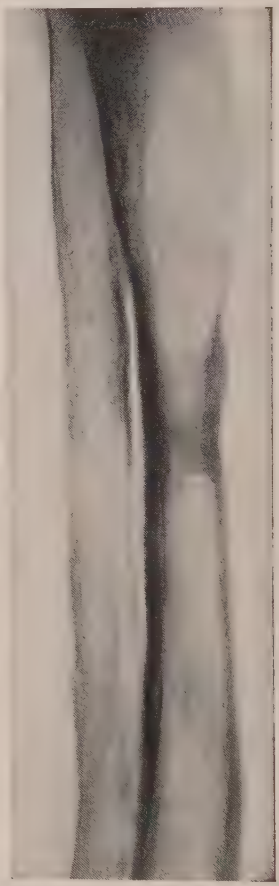


Fig. 356.—Syphilitic osteomyelitis of tibia and fibula.

ance of the community. In the Southern states, where the negro race forms a large proportion of the total population, bone syphilis in all phases is quite commonly found. The etiology is the *Treponema pallidum.* Trauma undoubtedly has a definite influence in producing osseous lesions in a syphilitic subject.

Pathology.—The destruction may be confined to a small area in one bone, to an entire bone, or may be distributed throughout the skeleton in various bones. The tibia is most frequently involved in acquired syphilis; in congenital syphilis the upper extremity of the ulna and radius is more frequently invaded, as well as the nasal bones, causing saddle nose. Dactylitis is also common in children with congenital syphilis; the bones of the phalanges are involved, causing fusiform indurated swelling of the finger or toe. Syphilis of the spine is exceedingly rare, but when present resembles other destructive processes, except that the destructive changes are far in excess of the symptoms.

Congenital syphilis in infants is manifested by an osteochondritis which is observed in infants and young children, rarely above the age of five years. In older children, the bone lesions are practically the same as those in acquired syphilis of adults. The early pathologic change in syphilitic osteochondritis, as described by Foote, consists of a central area of destruction in the shaft of a long bone, usually near the epiphyseal cartilage. The bone is replaced by fungous granulation tissue which interferes with the orderly process of bone formation and differs from other types of subacute bone inflammation by promptly infiltrating the epiphyseal cartilage toward the zone of calcification. An absorption of the matrix takes place, including calcified and noncalcified portions, with a replacement by the granulated tissue. This tissue breaks down at a later stage of the disease and is replaced by somewhat abnormal calcified tissue. The normally thin and even line of the calcifying zone becomes an irregular wide band, which later undergoes fatty degeneration, and the periosteum becomes thicker and more vascular. The new blood vessels from the marrow project into the cartilage and produce an appearance similar to that of rickets. This jagged appearance is not only observed in the roentgenogram, but is also perceptible in a gross section of the bone, and the bone marrow presents a salmon or yellowish color. While bone production in the zone of calcification is disturbed by the inflammation, osteogenesis in the periosteal area seems to be increased and bone is deposited in the cortical layers with accelerated speed. Congenital syphilis in late childhood, above the age of ten, and rarely between the ages of two and ten, may be manifested as a condensing osteitis, in which strata of the bone are apparently formed on the surface. This layer formation, however, may not be present, and there may be only an increase in thickness of the cortex with partial obliteration of the medulla. Rarely a destructive process may be present in children.

Acquired syphilis in bone is manifested as a destructive and proliferative process without the atrophic changes usually present in other affections. This is probably due to the fact that function is not usually impaired until very late in the course of the disease; in fact, arrest by treatment is usually accomplished before there is a loss of function. The two processes, degeneration and proliferation, are apparent, the classification depending upon the one which is in excess. The proliferative changes are manifested throughout the cortex of the bone as a condensation, but are more apparent beneath the periosteum. When proliferation is in excess, the lesion is termed "periostitis," but when the destructive changes predominate, the lesion is termed "osteomyelitis." Periostitis is a condensing osteitis, and, from observation, is apparently a precursor of the destructive changes. The cortex of the bone becomes increased in thickness and density at the expense of the medulla. Proliferation of the periosteum is accentuated on the convex curve of the bone which gives the appearance of bowing. When pronounced upon the tibia the condition is called saber shins on account of the resemblance to the old fashioned saber or sword. Syphilitic osteomyelitis is a disease of adult life and rarely occurs in children. The destructive stage of bone syphilis is manifested by areas of destruction and areas of increased density or proliferation, the destruction being in excess of the proliferative process. The roentgenogram shows the bone more or less honeycombed with cavities, intermingled with bone of increased density. The affected area, or the entire bone, is increased in size. The process may invade an epiphysis, causing separation or large abscesses filled with pus and necrotic detritus may form in the soft tissues from the breaking down of the bone. After intensive treatment is instituted the proliferation of bone is increased and there is a substitution of the destructive areas by dense bone. Gumma formation just beneath the surface of the periosteum may break through the periosteum, forming an excavated depression which is called a bone ulcer.

Symptoms.—The symptoms of osteochondritis in infancy are manifested by an enlargement in the region of the epiphyses with tenderness about the joints. The enlargement resembles rickets but is irregular. In infants the extremity may seem to be paralyzed and the limb hangs useless by the side; the paralysis may be present at or soon after birth. On palpation a definite enlargement may be present and the parents often regard the condition as due to an injury, fracture, or infantile paralysis. In congenital syphilis the manifestations in the bones may be the first symptoms to appear which is not fully appreciated. Fever

is not present, unless there is secondary pyogenic infection; swelling is variable but can usually be detected on deep palpation; tenderness is always elicited by deep palpation. Loss of function is outstanding in infants. The other stigmata of congenital syphilis, as Hutchinson's teeth, keratitis, snuffles, saddle nose, deafness, and skin eruption, are usually associated. In congenital syphilis of older children and in adults, the symptoms are manifested by a definite enlargement over the affected bone, which is often the tibia. The onset is gradual with pain and tenderness on pressure. The pain is not increased especially by activity, but is accentuated at night. Pain is largely due to impairment of the circulation and to increased intra-osseous tension, and is more prevalent when periostitis predominates, as bone of greater density prevents free circulation. When there is extensive osseous destruction which breaks through the surface, the tension is decreased and, as a rule, in syphilitic osteomyelitis the pain is less. Syphilitic osteomyelitis in congenital syphilis, or in osteochondritis, may cause a separation of the epiphysis. In acquired syphilis there is usually a history of the primary infection, a progressive enlargement of the bone and the other symptoms of increased intra-osseous pressure. Pathologic fractures are frequent in syphilitic osteomyelitis but rare in periostitis. Union occurs rapidly with or without antisyphilitic treatment. Fractures are more commonly observed in the humerus and are usually caused by slight trauma, as throwing a ball. Spurs of the os calcis are not common in syphilis, but when present are often massive. The adjacent joint may be invaded by direct continuity in adults, causing a painless arthritis.

Roentgenoscopy.—The gross pathology is demonstrable by the roentgenogram. The process is proliferative with massive enlargement of the bone, intermingled with areas of destruction or necrosis, but without bone atrophy. The roentgenogram in osteochondritis shows an irregular sawlike junction between the diaphysis and the epiphysis, which is produced by the jagged processes on the upper extremity of the diaphysis. The epiphysis, unless rickets is a complication, is of normal size. In congenital syphilis the first changes are frequently apparent on the surface of the bone, as a fuzzy proliferation of the periosteum. The periosteum may be laid down in strata or layers not unlike those of an onion. Rarely the first evidence may be an encroachment upon the canal or an opacity of the medullary substance. The proliferation of the periosteum may be in the form of fine bone trabeculae anastomosing and forming a so-called "lace work." The entire bone may be enlarged by the massive increase in size of the cortex with gradual

encroachment upon or obliteration of the medullary canal. The process may be intensified upon one surface, usually the convex side, giving the appearance of bowing of the shaft of the bone. A destructive process or gumma may be observed with proliferation and elevation of the periosteum over a small area forming a bone blister.

Syphilitic osteomyelitis is manifested by massive hypertrophy with areas of necrosis alternating with areas of increased opacity, but without bone atrophy. The hypertrophy of the periosteum persists, as well as the condensation throughout the entire bone, but the dense hypertrophied periosteum is gradually encroached upon and eroded by the destructive process.

Diagnosis.—Syphilis in bone does not present the same difficulty in diagnosis as syphilis of joints. The diagnosis can be made usually by the clinical findings and the roentgenogram, but should be confirmed by the blood Wassermann test. The statement has been made repeatedly that the Wassermann test is unreliable in bone and joint syphilis. This observation is absolutely unfounded; the blood Wassermann will be positive in about 90 per cent of those affected with bone or joint syphilis of acquired origin. In congenital syphilis, it is rarely possible to obtain a history of infection in the parents. The Wassermann test should, of course, be made on both parents when possible. The Kahn test may be made in addition to the Wassermann test and is almost as reliable. A routine spinal fluid examination is not indicated as a diagnostic measure. It is employed only when the blood Wassermann is negative and the clinical and roentgenological findings are suggestive, or when the neurological examination reveals symptoms indicative of cerebrospinal lues, as sluggish pupils, diminished or increased reflexes and sensory disturbances. If the blood and spinal fluid reactions are both negative and the lesion suggests syphilis, the therapeutic test should be employed; vigorous antisyphilitic treatment is administered for one month. If the lesion is favorably affected, the treatment is continued, otherwise, some other condition must be sought as the etiologic factor. Biopsy is rarely, if ever, indicated as a diagnostic measure.

The differential diagnosis of syphilis from other bone lesions can be made only by experience. The roentgenological visualization and comparison of various affections in bone are acquired by judgment through experience; such judgment is difficult to define, but a knowledge of syphilis in all its manifestations is necessary for the clinical interpretation of many disease processes. Differential diagnosis must be made between acute infectious osteomyelitis of the residual stage,

sclerosing osteomyelitis, tuberculosis, osteitis fibrosa cystica, giant-cell tumor, malignant tumors, and in infants from obstetrical paralysis, infantile paralysis, traumatic lesions and osteomyelitis. The fact that there is a definite and gross organic lesion in bone and a positive Wassermann reaction is not conclusive evidence that the lesion is due to syphilis, unless the roentgenogram is also suggestive of syphilis. If the lesion is characteristic of syphilis and the blood Wassermann is negative, a spinal fluid Wassermann should be made, which, if positive, confirms the diagnosis. Draining sinuses are more often present in osteomyelitis than in syphilis, and retained sequestra and cavities are more frequently observed. The surface of the periosteum is more irregular, often with small protruding exostoses. In bone syphilis with draining sinuses there is extensive necrosis throughout, intermingled with areas of increased density or condensation. By comparison of the two conditions, an error in diagnosis is seldom possible, even though the Wassermann test be positive.

Sclerosing osteomyelitis of Garré resembles syphilitic periostitis, but the increased density involves the entire cortex of the bone, forming a spindle-shaped mass with condensation throughout. In syphilis, hypertrophy is more pronounced upon the convex surface. Tuberculosis of the shaft is very rare and presents extensive necrosis, bone atrophy, and much less proliferation in both the cortex and periosteum of the bone. Giant-cell tumor and osteitis fibrosa cystica present such characteristic appearances that differentiation can always be made from a knowledge of these conditions. The various types of osteogenic sarcoma can be differentiated by clinical and characteristic roentgen-ray appearances. Metastatic carcinoma usually presents a typical mottling of bone which is usually generalized throughout the spine and skeletal system. In carcinoma of the bone, there may or may not be a previous history of the primary tumor. Metastatic carcinoma from the prostate gland to the femur and rarely in other bones may present a massive ossifying tumefaction of the entire bone with areas of increased and decreased density which differs from syphilis in that the hypertrophy is greater and the surface more irregular. This condition may be found rarely invading the entire pelvis.

In infants, differentiation must be made from obstetrical paralysis. In this condition, there is a history of difficult labor; the arm may be flaccid for a few days, but soon assumes the typical position of inward rotation of the forearm with limited abduction of the shoulder. The roentgenogram is negative. Infantile paralysis is rare in infancy, but when present is accompanied by a history of a febrile illness followed

by paralysis. Loss of function may be present after trauma, but rarely to the same degree as in syphilis; the roentgenogram will show the fracture with callus formation when present or the characteristic manifestations of osteochondritis. Osteomyelitis in infants may cause a definite flaccid paralysis, but a history of characteristic elevation of temperature is usually available.

Prognosis.—The prognosis of bone syphilis is excellent with efficient treatment; a return to normal function may be anticipated, unless there has been a dissolution in continuity of the bone. When an epiphysis is separated or destroyed, even though the process itself is eradicated, the organic changes may be irreparable. Virulent cases are occasionally seen which do not respond to any form of treatment.

Treatment.—Intensive antiluetic measures are indicated. Maximum doses of arsphenamine, adjusted to individual tolerance, should be given intravenously at seven-day intervals over a period of six weeks. Intramuscular injections of mercuric salts or inunctions of mercury are also administered. Sodium iodide intravenously or potassium iodide by mouth is given at the same time. In children, sulpharsphenamine may be substituted for arsphenamine when the latter can not be injected satisfactorily. In the author's experience, sulpharsphenamine is effective upon the local process, but does not have an equally beneficial effect upon the constitutional symptoms; the Wassermann reaction remains continuously positive. Injections of bismuth have been advised in congenital syphilis but are probably not superior to arsphenamine. After six intravenous injections of arsphenamine, the Wassermann test is repeated. An intermission in treatment for one month is allowed, regardless of the result of the test. At the end of the month, a second series of six doses of arsphenamine is given at weekly intervals. Mercury and iodides are again administered, and in some cases must be continued over a long period of time. Treatment should be continued until the Wassermann test is negative and the patient is clinically free of symptoms. In congenital syphilis, the Wassermann may remain persistently positive and treatment may be required, at intervals, for years before a negative reaction is secured, although clinically, all evidence of lues may have disappeared. Surgery is very rarely indicated, as the process recedes usually under specific therapy. However, retained sequestra which are causing persistent drainage should be removed. Correction of residual deformity also may require operative measures.

SCLEROSING OSTEOMYELITIS OF GARRÉ

Sclerosing osteomyelitis is a rare affection described by Garré. The etiology is unknown, but the cause is probably a low-grade infection; trauma may be a predisposing factor. The affection occurs usually during late childhood, and is more frequently observed in boys than girls. The shafts of the bones, especially the tibia, are affected more frequently; however, the process may involve the cavernous structure at the extremities of the bones. Several bones may be affected simultaneously, or rarely the disease may be bilateral.

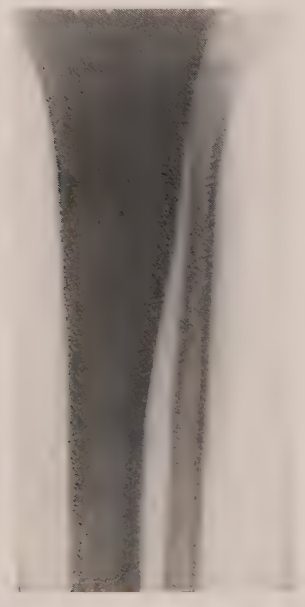


Fig. 357.—Sclerosing osteomyelitis of upper end of tibia, with increased density of bone. Anteroposterior view.

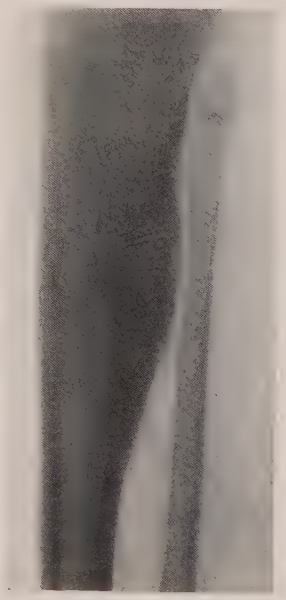


Fig. 358.—Same as Fig. 357. Lateral view.

Pathology.—The affected area of the bone is hypertrophied with considerable thickening and proliferation of the cortex. The entire dimension of the bone is involved, producing a spindle-shaped enlargement. Suppuration and sequestration do not occur; sinus formation is rare, although ulceration of the skin over the hypertrophied area may be observed. At operation, the cortical portion of the bone is found to be extremely dense, the cancellous bone is softer than normal and the medullary canal is filled with chronic inflammatory tissue.

Symptoms.—The onset is usually slow and insidious, but may be acute with elevation of temperature, swelling of the affected limb and

intense local pain. The pain, as a rule, is of a dull aching character and is definitely localized over the site of the bone lesion. The subcutaneous tissues are edematous; on palpation the bone is found to be hard, smooth in contour and tender. Increased intra-osseous tension may be demonstrated by deep, firm pressure over the affected area. In subcutaneous bones, such as the tibia, ulceration of the skin may be observed in the advanced stages. The roentgenogram demonstrates a spindle-shaped enlargement in the shaft of the long bones with increase in density. The surface is smooth and regular; the central canal may be obscured by the hypertrophied cortex. In cancellous bone, the affection produces sclerosis, periosteal thickening, and eburnation.

Diagnosis.—The diagnosis is usually possible by the symptoms and local manifestations, but differentiation must be made from syphilitic periostitis which it may closely resemble. In bone syphilis, the Wassermann test is positive in about 90 per cent of cases. The new bone is deposited in a more irregular manner and in the roentgenogram areas of destruction may be demonstrated. The periosteal proliferation of syphilis is usually more exaggerated on the convex surface of the bone, whereas, in sclerosing osteomyelitis, there is a spindle-shaped enlargement about the entire circumference of the affected area.

Prognosis.—The prognosis is uncertain; the disease may persist for years, regardless of treatment, but usually terminates spontaneously. The symptoms are relieved although the structure of the bone may never return to normal.

Treatment.—Roentgen-ray therapy has been employed, but without apparent improvement. Because of the close resemblance to syphilitic periostitis, vigorous antisyphilitic measures have also been advised, but with no relief of symptoms or change in bone structure in most instances. Surgical treatment seems to have the most beneficial effect upon the pathologic process, although the disease is not always arrested, even by such measures. Two methods of operation may be employed. In the first, an incision is made over the affected area down to the bone and the periosteum is elevated. Numerous drill holes are made through the cortex into the central canal, after which the wound is closed. The second method is a more radical procedure, consisting of the removal of a portion of the cortex over the affected area, curettage of the medullary cavity and closure of the subcutaneous tissues and skin without drainage. Cessation of pain usually occurs immediately after the operation and is apparently due to the relief of intra-osseous tension, but the symptoms may return when the cortex is replaced by new-bone formation.

OSTEITIS FIBROSA CYSTICA

Osteitis fibrosa cystica, or bone cyst, is a rare affection of bone occurring in children, and is usually observed from the age of four years to adolescence. The etiology is undetermined though there is a theory of infection and trauma. The process may be local or generalized; when general, it is associated with osteomalacia in rare instances. The most common site of occurrence is the upper or lower extremity of the femur and humerus. There is fibrous substitution of bone with gradual thinning of the cortex, which may form one large cyst or multilocular cysts separated by thin partitions of bone. Rarely, there may be dull aching, or no local symptoms may be present. The first manifestation is usually a fracture through the affected area caused by some slight injury, or by less force than would ordinarily cause a fracture in normal bone. In the generalized type, extensive deformity may occur, and when associated with osteomalacia, permanent invalidism is probable. The roentgenogram shows characteristic changes from which the diagnosis is made. When the process is local, there may be a close resemblance to giant-cell tumor. However, differentiation is unnecessary, as the treatment and clinical course are the same. In osteitis fibrosa cystica, the roentgenogram shows a cyst within the bone and thinning of the cortex. The cortex, however, is rarely expanded, whereas, in giant-cell tumor the cortex is usually expanded. Tuberculosis, osteomyelitis, and syphilis may be differentiated by the history, clinical manifestations and roentgenogram.

Fig. 359.—Osteitis fibrosa cystica of upper end of femur. Note multilocular cyst without expansion of bone cortex.

The prognosis is excellent when the affection is local, and the process may terminate in spontaneous recovery; when generalized, spontaneous recovery usually occurs, but often with severe deformity which may seriously impair function. When osteomalacia is associated no improvement is to be expected. Complicating fractures unite as readily as simple fracture in normal bone, and may often have a beneficial influence upon or arrest the process. In the local type conservative treat-

ment should be employed unless the process is advanced. Roentgenotherapy may be beneficial. Surgical procedures are indicated when deformity or fracture is impending. The operation consists of opening the bony cavity and crushing in the wall so that small bony particles may partially fill the cavity. Particles of bone should also be removed from normal bone adjacent to the cyst or from a distant point, as the tibia, and placed into the cystic area. These particles are multiple grafts, capable of osteogenesis and may reproduce strong, healthy bone, thus reinforcing the defective area. Deformity should be prevented by appropriate apparatus, and if first observed after deformity has occurred, correction may be made by plastic procedures on the bone and contracted soft tissues.

RICKETS

Rickets is an acquired constitutional disease of infancy and early childhood. Many if not all of the tissues of the body may be affected, but the manifestations in the bones are more easily recognized. The etiology depends upon a nutritional abnormality which may be due to a deficiency of calcium and phosphorus in the diet, or to a lack of assimilation from the intestinal canal. Race is an important factor. In America, the most pronounced manifestations of the disease are seen in children of negro and Italian parentage. Lack of sunlight has also proved to be an etiologic factor. Rickets is a disease of the temperate climates, being unknown in the tropical and arctic regions. It is more frequent in the cities and less frequent in rural communities. The poor suffer most but the children of the well-to-do are not exempt.

Pathology.—The changes in the skeleton produced by rickets are definite and characteristic, and consist of disturbances of endosteal and periosteal bone formation and disturbances of endochondral ossification. An excessive amount of osteoid tissue or bone without lime salts is formed in the interstices and on the surface of the bone. The excess of osteoid tissue is most pronounced in those bones in which growth is most rapid, and in those locations in which the bone is subjected to mechanical strain. The bones are more flexible than normal and consequently may become greatly misshapen. This applies especially to the ribs, the bones of the extremities, and those of the skull. On microscopical examination, the normal growth of the bone is disorganized, as demonstrated by irregularity in the arrangement of the cells in the epiphyseal cartilages. Each bone column or trabecula is seen to be surrounded by an abnormally wide zone of nonlime-containing tissue. An effort is apparently made to compensate for the weakness by the production of an excessive amount of osteoid tissue to add strength to

the vulnerable areas. These accumulations are found beneath the periosteum in the neighborhood of the epiphyseal lines and replacing the bone marrow. Instead of a narrow transitional zone at the epiphyseal line, there is in rickets a zone many times the normal breadth, not sharply limited, but irregular in contour and greatly distorted, especially when weight or muscular action has produced a partial dislocation of the epiphysis upon the diaphysis. The zone is composed of cartilage cells, blood vessels derived both from the marrow and the cartilage, osteoid tissue and connective tissue, in a most disorderly and irregular arrangement.

Symptoms.—The constitutional symptoms are mild; infants are fretful and restless and older children may show a marked apathy and lack of desire to play. Sweating about the head is frequent and anemia to a greater or lesser degree is usually present. The abdomen is usually prominent, the spleen is enlarged and intestinal disorders are frequent. There is a lack of muscular tone evidenced by flaccidity of the muscles. In infants, delay in closure of the fontanels, especially the anterior fontanel, is commonly observed. The shape of the head is altered by the development of bosses on the parietal and frontal bones, as a result of which the head becomes square in shape. There is a diffuse enlargement of the extremities of the bones, more pronounced in the wrist, ankle, knee, elbow, shoulder, and sternal end of the ribs. A transverse groove across the anterior surface of the thorax with flaring of the lower borders of the ribs is known as Harrison's groove. The thorax is compressed laterally and the enlargement of the ribs is palpable, being known as a rachitic rosary. "Funnel chest" or "pigeon breast" may be present, but these deformities are not always due to rickets. The spine may show a rounded kyphos in the dorsal and lumbar regions when the child is sitting, which disappears in the recumbent position. Scoliosis may also result from rickets and when untreated may persist throughout life. Deformities of the extremities are very common; the curvatures of the long bones depend upon the attitudes assumed and whether or not weight has been borne upon the leg. The most common deformities are bowleg, knock knee, scoliosis, coxa vara, and bowing of the humerus, radius, and ulna. The roentgenogram, as a rule, is characteristic. There is a cupping of the lower portion of the shaft of the bone, cloudiness or haziness in the region of the epiphysis, with an irregular fringelike appearance between the shaft and the cartilage in the metaphysis. The ends of the shafts of the bones are also broader than normal.

Prognosis.—The prognosis is excellent. The disease is very seldom

fatal, but the evidence of rickets usually persists in some of the bones throughout life. As the process subsides, there is a tendency toward spontaneous recovery, and the normal growth of the epiphyses is re-established.

Treatment.—The prophylactic treatment is most important and is in the domain of the pediatrician. Constitutional treatment consists of regulation of the diet by the addition of such foods as will supply the required amount of calcium and phosphorus. Heliotherapy undoubtedly has a beneficial effect upon the process independent of diet, and should

Fig. 360.—Roentgenogram showing epiphyseal disturbance characteristic of rickets. Anteroposterior view.

be routinely employed. Actinotherapy by the use of the ultraviolet rays is indicated when natural sunlight is not available. Cod liver oil should be given in 1 or 2 drachm doses three times a day, as vitamin D which is present in cod liver oil seems to have a specific action upon the disease process. In severe cases, during the period of activity, the child should be maintained on a Bradford frame, or other hard surface until the roentgenogram demonstrates that the structure of the bones is returning to normal. This requires from three to six months. Deformities in the lower extremities may be prevented by not allowing the child

to walk and by the use of simple splints to maintain the limbs in the normal position. Residual deformities, such as bowleg and knock knee, require special treatment and consideration.

Bowleg (Genu Varum).—Bowleg is an outward bowing through the upper and middle thirds of the shafts of the tibia and fibula, with an inward rotation or twist of the lower third. If the condition is observed while the process is still active, correction may often be accomplished in mild cases by repeated manual manipulations; both extremities of the leg are grasped and bent outward for a few minutes three or four times

Fig. 361.—Same as Fig. 360. Lateral view.

daily. A simple bowleg splint, consisting of an inner bar extending from foot to thigh, with a broad strap making pressure over the apex of the curve may also be applied. This splint should be worn during rest periods in the day and at night. If the deformity is severe, walking-braces which make a definite pull or pressure over the curve, may be employed. After the subsidence of the process, if the deformity is exaggerated, operative procedures are required. Fracture without incision by an osteoclast or an open osteotomy with a chisel is performed at the greatest prominence of the tibia, which is usually in the upper third; the fibula is then fractured manually, after which a plaster

cast, extending from the toes to the groin and retaining the limb in slight knock knee or the overcorrected position, is applied.

Knock Knee (Genu Valgum).—Knock knee, as the term valgum indicates, is an outward deviation of the leg on the thigh. An angle is formed with the femur at the knee joint, and there is also outward rotation in the exaggerated cases. In walking, the feet usually turn in (pigeon toe) in a compensatory effort to clear the knees. However, flatfoot, instead of pigeon toe, may be a complication, especially in those who develop the habit of rotating the hips outwardly. The prognosis for spontaneous recovery is not so favorable as in bowleg, though

Fig. 362.—Bowleg deformity following rickets.

Fig. 363.—Same as Fig. 362. After operative correction.

Fig. 364.—Knock-knee deformity following rickets.

material improvement may often be observed after normal growth has continued for a number of years. As in genu varum, daily manual manipulation is indicated during the active stage, and consists in grasping the lower extremity of the femur with one hand and the ankle with the other, and bending the leg inward with the internal condyle of the femur as a fulcrum. Corrective splints are also applied during rest periods in the day and at night. Steel braces extending from the foot to groin, with straps holding the knee outward and the leg inward, are required for ambulation when progressive deformities are present. After the active process has subsided deformities are

corrected by operative procedures. The femur is fractured just above the epiphysis by an osteotome or an osteoclast, producing a fracture at the desired point. The limb is then immobilized in a plaster cast in the overcorrected position until union is solid.

Latent Rickets.—Late or latent rickets is a process with manifestations similar to those of rickets, but which occurs about adolescence or puberty. There is usually a history of rickets in early childhood, which has apparently remained quiescent for years. The treatment is the same as that employed in rickets.

OSTEOMALACIA

Osteomalacia is an affection of the bones occurring very rarely in childhood, but is seen more frequently in women during pregnancy and is characterized by decalcification of bone. There is shortening of the bones due to longitudinal pressure on the softened bone structure, with bending, fractures, and distortion. Fracture from slight trauma is common, but the bones usually unite as readily as in fractures of normal bone. Defective nutrition may be an etiologic factor, as the condition has been observed recently in Europe where the inhabitants have been on a starvation diet. The bones are of abnormal shape and softened; both the compact and cancellous tissues are atrophic. The bone marrow may be hyperemic, lymphoid or edematous, and occupies a relatively greater proportion of the bone structure. In typical cases, the most marked changes are seen in the bones of the pelvis. The muscles are atrophied but the joints are not usually affected. Pain is the earliest symptom, and is later associated with weakness and stiffness. The roentgenogram shows atrophy of the bones, which become indistinct and present a loss of contrast with the soft tissues. Various endocrine preparations, such as adrenalin and pituitary extracts have been recommended, but the treatment is largely symptomatic.

SCURVY

Scurvy, or scorbutus, in children is caused by the lack of raw foods, and may be observed in families of the higher classes, especially in infants whose food has been thoroughly sterilized by heat. As an orthopedic problem, scurvy is manifested by painful epiphyses and subperiosteal hemorrhages which cause lameness. The child may show other well known manifestations, such as petechial hemorrhages of the mucous membranes and skin. The roentgenogram may demonstrate changes in the epiphyses somewhat similar to rickets. The treatment consists in the regulation of diet with sufficient raw food, as fruit juices, etc.

OSTEITIS DEFORMANS

Osteitis deformans is a disease of bones characterized by enlargement, softening, and distortion. The condition was first described by Sir James Paget, and is commonly known as Paget's disease. The etiology is unknown, but males are affected more often than females and the disease occurs usually after the age of forty years. The bones become progressively thicker, the compact bone being chiefly involved, and the cortex of the long bones may be four or five times thicker than normal. The thickening is accompanied by the combination of rarefaction and sclerosis, the bones eventually becoming very hard. The shafts of the bones are heavier, thicker, and curved, and the flat bones, especially those of the skull are greatly increased in size. The preliminary symptoms are pain in the limbs, stiffness in the back, and malaise. The patient notices a rapid decrease in height, increase in size of the head, and bowing of the lower extremities. Fracture of the bones is rare, but sarcoma frequently develops. The prognosis is unfavorable, the disease is incurable, and the treatment is only palliative.

OSTEOPOROSIS

Osteoporosis, or bone atrophy, follows prolonged immobilization or inactivity of any part of the body. There is an abnormal porousness or rarefaction of the bones by the enlargement of the haversian canals, and by the formation of cavities. The condition is described here as a clinical entity, but is in reality a symptom of various affections of bone as fractures, dislocations, sprains, and certain forms of arthritis. The atrophic changes, in many instances, are caused solely by disuse, but the distinction must be made between osteoporosis per se and osteoporosis occurring as a symptom of tuberculosis or other form of arthritis. The chief symptom is pain which is persistent and aggravated by attempts at function, which produces a vicious cycle. The treatment consists of physiotherapy and measures to induce increased circulation in the extremity and the gradual resumption of normal function. Braces and splints are often necessary to furnish support and prevent deformity.

CONGENITAL DEFICIENCIES IN QUALITY OF BONE

Fragilitas ossium, idiopathic osteopsathyrosis, osteogenesis imperfecta are the terms employed to describe an affection in which there is an inherent congenital abnormality of quality in osseous tissues, which may be apparent at birth or during early childhood. The bones fracture repeatedly from very slight injuries, and undoubtedly, this

condition is often observed in a mild form, as many children are subject to repeated fractures. The etiology is obscure, though a history of the same affection may occasionally be obtained in other members of the family. Apparently, the process of growth is not normal, osteogenesis being too rapid. Normal bone is derived from bone cells, whereas, in fragilitas ossium, bone apparently is produced directly from cartilage. These individuals are often of peculiar appearance, suggesting endocrine disturbance. The roentgenological findings are rather indefinite, technical, and not of practical diagnostic importance. The first symptom is a fracture from a very slight force, as turning in bed, and subsequently repeated fractures occur. Deformities are unavoidable and the individual usually becomes a hopeless invalid. The only treatment is the prevention of deformity by appropriate apparatus. Neither organotherapy nor any other remedy which has been suggested has a beneficial effect.

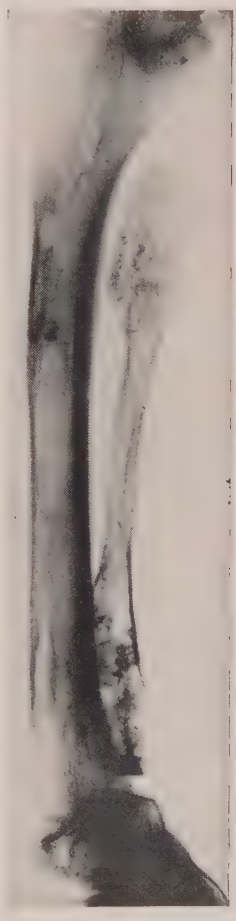


Fig. 365.—Characteristic changes in dyschondroplasia.

Osteosclerosis.—Osteosclerosis, or marble bone, is a congenital affection of the bones, in which the roentgenogram demonstrates an increased density. The condition has been observed in father and son and therefore heredity is given as a factor. No cause is known. Destructive and proliferative changes in the joints occur in childhood, but the condition is of such rare occurrence as to deserve only mere mention.

Dyschondroplasia is a rare affection of the bones occurring in childhood, characterized by the development of bone into osteoid tissue, which is a mixture of bone and cartilage, with a diminution of lime salts. The epiphyses are not involved, and actual growth is apparently normal; there is, however, marked shortening in the bones due to longitudinal pressure on the softened bone structure, with consequent distortion. Fracture from slight trauma is common, but the bones usually unite as readily as in fractures of normal bone. The process may be local or diffuse throughout the skeleton. When local, one of the extremities may be

involved, and the other portions of the skeleton may be normal. In the diffuse type, the prognosis is unfavorable, as there may be extensive distortion and deformity throughout the entire skeleton. No form of treatment has proved beneficial, but the process usually subsides when full growth is attained. Retentive apparatus should be employed for the prevention of deformity.

Chondrodysplasia foetalis is apparent at birth and has been erroneously called fetal rickets. However, the process is a complex embryological condition and has no relation to rickets. The child is

Fig. 366.—Dwarfism and typical deformities of chondrodysplasia foetalis.

Fig. 367.—Same as Fig. 366. Lateral view.

dwarfed, does not attain full growth, the head is square, the forehead prominent, and the body or trunk is out of proportion in length to the legs. There may be multiple deformities and the epiphyses show enlargement. Prevention of deformity by apparatus is indicated, but is not very effective. No other measure is of value.

Multiple enchondroma or osteochondroma is a condition characterized by the formation of hard dense tumors in the region of the epiphyses. The affection may be hereditary. The symptoms are evidenced only by the mechanical action on the joints, which may interfere

with locomotion or cause pain by pressure. When such symptoms are present, removal by operative procedures is indicated; otherwise no treatment is necessary.

Fig. 368.—Chondrodysplasia foetalis in adult with dwarfism.

Fig. 369.—Enchondroma of phalanx.

Fig. 370.—Same as Fig. 369. Showing enchondroma of phalanx.

ENDOCRINE DISTURBANCES

Abnormalities in the bones resulting from an imbalance of the endocrine system may occur. The spine and joints may rarely be involved in such a process, which may permanently impair function and induce deformity. There are typical changes in the epiphyses in cretinism and also in gigantism which are characteristic. Acromegaly, a con-

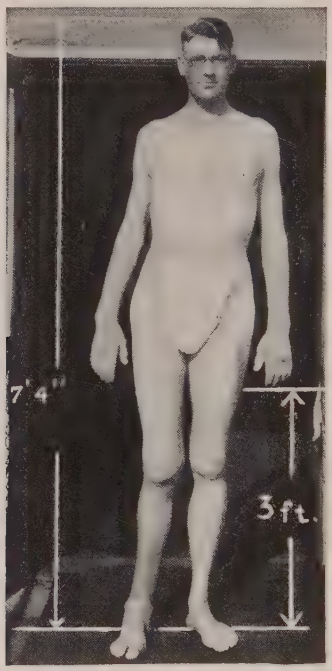


Fig. 371.—Gigantism caused by disturbance of pituitary gland.

dition associated with hypopituitarism, is characterized by hypertrophy of the bones and soft parts of the face, hands, and feet. Organotherapy may be administered in the early stages, but when the process is advanced, no treatment is of any value.

BIBLIOGRAPHY

Foote, John A.: Diseases of the Bones, Joints, Muscles, and Tendons, Clinical Pediatrics Series, New York, D. Appleton and Co., 1927, p. 136.

Garré, C.: Ueber besondere Foramen und Folgezustaude der akuten infectiosen Osteomyelitis, Beitr. z. klin. Chir., 10: 241, 1893.

Orr, H. W.: The Treatment of Acute Osteomyelitis by Drainage and Rest, Jour. Bone and Joint Surg., 9: 733, 1927.

Paget, Sir James: On a Form of Chronic Inflammation of Bones (Osteitis Deformans), Med. Chir. Tr., London, 60: 37, 1877.

CHAPTER XIII

BONE TUMORS

The subject of bone tumors is confusing, the literature abounds in numerous names for the same specific tumor, and often the same terminology is employed in various parts of the world to designate different clinical entities. This chaotic state is possibly due to the fact that the etiology of tumors is still unknown, or at least, purely theoretical, and also that the opinions of eminent pathologists are at variance as to the nature of the component elements of many tumors. Among the numerous theories of etiology that have been suggested are heredity, injury, and inflammation. Physiologic activity favors the development of sarcoma, and physiologic decline is associated with the growth of carcinoma. Most authorities admit that trauma and irritation predispose to the development of tumors. Other authorities think that cancer is contagious and is caused by bacteria or one of the yeast organisms, but the presence of these organisms is more likely to be due to contamination. Pfeiffer and Adamciewicz have asserted that the cancer cell is not a body cell but is a parasite. Butlin believes that cancer cells are parasites and act independently like protozoa. Most authorities deny this theory, because if it were true, there would have to be a specific parasite for each tumor, or all tumors would be alike and also, if true, tumors would be infectious. The theory of disturbance of the equilibrium of tissues, suggested by Thiersch, is that with senility the energy of growth of the connective tissue cells fails so that epithelium invades it and grows at will. Waldeyer offers the reverse explanation, stating that failure of epithelium to maintain its ranks enables the connective tissue to surround and isolate some of the epithelial cells which then proliferate irregularly. Ribbert assumes that the most important and indispensable basis for the origin of tumors is the independence of the tissue germ attained through isolation of the cells by which the always adequate capacity for growth of cells is liberated. However, not every isolated group of cells forms a tumor. The character of the tumor depends upon the type of tissue in the rudiment, its degree of independence and its growth energy. Ribbert believes that isolation might occur in embryonic life or in adult life. Cohnheim's theory is that at some stage in embryonic development the cell becomes

isolated while still possessed of great energy of growth and potentiality to reproduce tissue. The cell may lie dormant for years and when stimulated begins to grow rapidly. Hauser, Marchand, Beneke, and Ziegler believe that the origin of tumors lies in a profound change in the character of the cells. Hansemann explains this change in the cell by a process which he describes as "anaplasia." The change consists in an alteration in the histologic character rather than in form, which allows the cell to proliferate rather than functionate. The theory of development of bone tumors promulgated by some physiologists is that all premature connective tissue cells are capable of differentiation into cells that may produce bone. If this were true, there would be no occasion to distinguish between osteogenic cells, or cells capable of producing bone, and those residing in bone. However, this theory is by no means generally acceptable as the majority of physiologists believe that bone is formed by a specially differentiated cell from the mesodermic layer, a mesoblast, whose only and special function is to form the tissues produced by the evolution of bone.

The Sarcoma Registry of the American College of Surgeons has done much to simplify the classification and disseminate knowledge of this most important subject, but at present, no complete classification based upon etiology or pathology is possible. There are, however, certain clinical entities which may be designated by names which are more or less appropriate. The classification of tumors by the roentgen ray, while excellent from the standpoint of the clinician and pathologist, considers other lesions of bone besides tumors. The terms employed by the Registry will be adopted as far as possible, but in this presentation of the subject the following classification will be employed.

Tumors Occurring in Bone

Benign: Osteoma, osteochondroma, chondroma, giant-cell tumor, angioma.

Malignant: Osteogenic tumors, or those derived from bone: Osteogenic sarcoma, Ewing's sarcoma.

Tumors occurring in and around bone not derived from osseous cells: Myeloma, periosteal fibrosarcoma.

Metastatic: Epithelioma, carcinoma, hypernephroma.

A benign bone tumor is one which arises primarily in bone and does not metastasize to any other portion of the body, and though it may reach a large size, recur after removal, and cause serious damage, it always remains localized. A malignant tumor is one which invariably metastasizes if growth is not arrested spontaneously, or eradicated by

some form of treatment. The benign tumors always arise primarily in the bone. The malignant bone neoplasms may be either primary or metastatic; as the name implies, metastatic tumors are secondary to malignant processes originating elsewhere in the body, and the etiology is different from those arising primarily within the bone. Both benign and malignant tumors of bone are derived from osteogenic cells which are capable of forming bone, or from the nonbone producing cells occurring in bone, as those of the blood vessels or in the bone marrow. Only the tumors of more common occurrence or well known clinical entities will be considered.

BENIGN BONE TUMORS

Benign tumors are osteoma or osteochondroma and chondroma. The benign tumors are neoplasms formed from cells which are capable of producing bone, or of becoming differentiated into bone, or of becoming bone-forming cells by evolution. Such osteogenic cells are derived from the primitive mesoblast, which is capable of developing into those elements which are produced in the evolution of bone, *i. e.*, myxomatous tissue, hyaline tissue, osteoid tissue, cartilage, and osseous tissue. Cells forming all these tissues may be present in varying proportions, from the primitive cells to the well-developed osteoblast from which bone is formed.

Osteoma and Osteochondroma.—Osteoma or a benign tumor composed entirely of bone is practically never observed, except as the result of trauma or inflammation, in which case there may be an outgrowth of bone as a result of irritation. This reaction is not a new growth but simply an exostosis. In osteoma, bone is usually associated with cartilage and the tumor is therefore in reality an osteochondroma. These tumors may occur singly or multiply; if of the latter type they are often of congenital origin and may be diffuse, affecting the extremities of all or many bones. The term "multiple enchondroma" is also used to describe this type of tumor. In single tumors, there is often a history of definite trauma. Osteochondromas occur in the extremities of bone near, but not in, the region of the epiphyses. The most frequent location is on the inner aspect of the lower extremity of the femur; the upper extremity of the tibia and humerus may also be involved. The tumors occur more often in youth, especially about adolescence, though they are frequently observed in very young children. They are composed of normal bone and are attached at the base by a small or large pedicle to the parent bone. The central osseous portion consists of normal bone with the formation of an haversian system, while the per-

iphery is composed of hyaline cartilage. There is a definite capsule and bursae may often be developed from irritation caused by the play of surrounding muscles. Microscopical examination will demonstrate normal bone at the base of the tumor and hyaline cartilage at the periphery; rarely myxomatous tissue may be found within the tumor, especially near the periphery.

No symptoms nor abnormality may be apparent except a mass of bone on palpation, which may be accidentally discovered by the patient. These tumors rarely grow to large size, but on palpation a cauliflower-like

Fig. 372.—Osteochondroma of upper end of fibula.

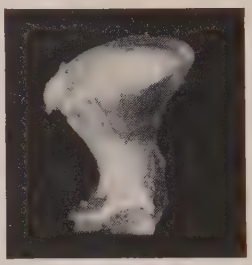


Fig. 373.—Osteochondroma after removal from scapula showing narrow base and pedicle. Anteroposterior view.

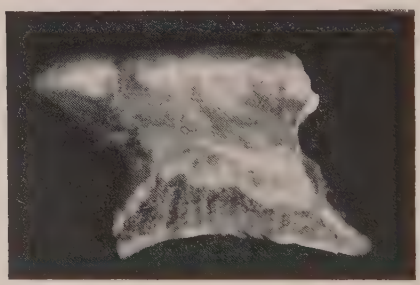


Fig. 374.—Same as Fig. 373. Lateral view.

growth may be felt, which may be of sufficient size to interfere materially with the function of the adjacent joint. Irritation with pain and disability from traumatic irritation may arise from actual pressure. The roentgenogram will demonstrate the osseous mass; two views are always necessary, as in one view the mass may be obscured by the parent bone; often it is necessary to make several radiograms from various angles to demonstrate the true size, dimensions, and shape of the tumor. The prognosis is always good if tumor is completely excised, and if properly treated by surgery in the early stage there should be no recurrence.

Rarely, in single tumors there may be a retrogressive process which results in the tumor's becoming malignant, and in possibly 5 per cent of the congenital or multiple type, malignancy occurs.

Treatment.—The treatment consists of early and complete excision of the tumor with a small area of the surrounding normal bone. When the tumor is attached by a pedicle the base should be thoroughly undermined; the capsule and the bursa, when present, should also be excised. Rarely, at the periphery, loose cartilaginous bodies may be found free in the tissues; these can usually be removed easily as they do not invade the surrounding tissues extensively.

Chondroma, as the name implies, is a tumor composed of cartilage, usually of the hyaline variety, though there may be an admixture of fibrous tissue. These tumors occur more often in adult life and are usually observed about the popliteal space; apparently they arise from the head and upper extremity of the fibula. They are lobulated tumors and may invade the soft tissue extensively, but have a definite fibrous capsule. A hard lobulated mass may be elicited on palpation and the roentgenogram will demonstrate a flocculent mass attached to the bone, which may remain intact or become invaded from pressure of the tumor; at times there may be actual osseous destruction. There are no symptoms except those which may arise from mechanical pressure on nerves and vessels. Microscopical examination will demonstrate lobulated masses of hyaline cartilage separated by fibrous tissue; connective tissue cells may be found in increased numbers, but the structural arrangement is always orderly. At times, myxomatous tissue may be found on the interior of the tumor. These tumors, while essentially benign in the early stage, often undergo malignant metaplasia, and metastasis may occur; unless they are excised completely, recurrence with increasing severity and often with malignant change may be expected. The prognosis should always be guarded, and after excision the patient should be kept under observation for many years.

Treatment.—The result of operative or roentgenological treatment is doubtful. Complete excision is indicated in all cases, and if there are repeated recurrences, total excision or amputation is necessary. Radiation should be administered before and after operation. After a recurrence, if there are malignant changes demonstrated by microscopical examination, amputation, when the location will permit, is imperative.

Giant-cell tumor occurring in bone has been commonly termed "giant-cell sarcoma," but the term "sarcoma" implies malignancy and should be discarded. In Great Britain this tumor is called myeloid sarcoma and myeloma; the latter term is employed in this country to

describe an entirely different type of tumor occurring in bone. The tumor has also been described by Barrie as hemorrhagic osteomyelitis. The term "giant-cell tumor" is used because giant cells of a certain type are found in the tumor and are characteristic of it, although they do not comprise the entire tumor and all other cells which are found are those commonly observed in inflammatory processes. There are two views as to the actual nature of giant-cell tumor. One group of observers regards it as a type of chronic inflammation and does not believe the lesion is a new growth, while others regard the tumor as a

Fig. 375.—Giant-cell tumor of radius with multilocular cyst and expansion of bone cortex. Anteroposterior view.

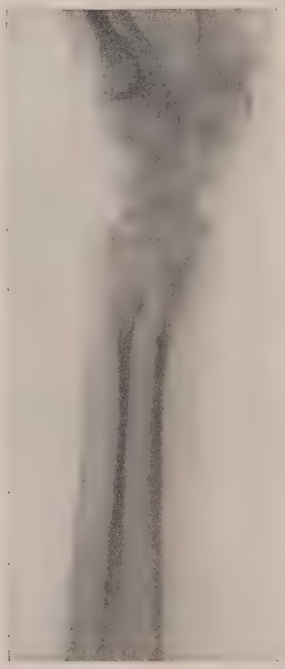


Fig. 376.—Same as Fig. 375. Lateral view.

true neoplasm. At present the condition is classified as a tumor even though the exact nature is not understood. Trauma may be an etiologic factor as a history of definite injury is often obtained. Giant-cell tumors are much less frequent than malignant bone tumors. They occur slightly more often in females than in males, and more frequently in adolescents and young adults, rarely in young children or after middle age. The bones of the lower extremity are involved more often than any other portion of the skeletal system. The tumor occurs usually in the end of the bone, just beneath the articular cartilage, and may invade

the epiphysis but rarely the joint. The lower extremity of the femur and the upper extremity of the tibia are more frequently involved. The shaft of a bone may be the site of a giant-cell tumor.

There may be pain of a moderate degree and when the bones of the lower extremity are involved, there may be a slight limp. There is a history of gradual enlargement of the bone extending over a period of many months or years. The tumors seldom develop to as large a size as they did in the past, because they are usually discovered and removed at an earlier stage. The mass may be palpated, and in those in whom the bone is greatly expanded there may be elicited a definite "crackling." Rarely, in the more vascular tumors a bruit may be elicited by auscultation. As the process advances, the joint may be invaded with incident

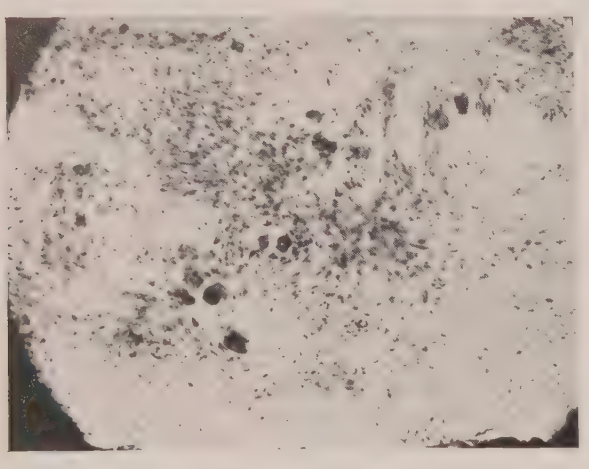


Fig. 377.—Giant-cell tumor.

arthritis. Before the joint has become involved there is often a definite enlargement of the bone adjacent to the joint, which may be palpated. Tenderness is also present but pain is not severe. Motion is often limited in certain directions, but is rarely markedly restricted until there has been extensive destruction of osseous tissue. In those affecting the lower extremity of the femur, an arthritis of the knee may be suspected, but all symptoms are above the joint, though there may be slight limitation of function, especially in extreme flexion which is caused by mechanical pressure and tenderness of the tumor. On palpation there may be moderate pain, but there is no indication of marked intra-osseous pressure. The tumor is essentially benign and should be so regarded, although metastasis to the lungs has been reported. The roentgenogram shows a central lesion in the extremity of the bone, which is greatly

expanded and divided in the interior by bone trabeculae into multilocular compartments or cysts, giving the so-called "soap-bubble" appearance. The bone destruction and thinning of the cortex is demonstrated by the roentgenogram and in this respect giant-cell tumor resembles osteitis fibrosa cystica. However, in giant-cell tumor, the cortex of the bone is usually expanded, whereas in osteitis fibrosa cystica, there is no expansion of the cortex. The periosteum can usually be seen limiting the tumor. The former shaft of the bone may have entirely disappeared or been practically obliterated, depending upon the duration of the process.

Pathology.—The giant-cell tumor is located centrally within the bone and the process is one of destruction. The growth is slow and the bone is gradually expanded, until only a shell of the cortex remains. There is a reaction on the part of the surrounding bone which forms new bone over the advancing tumor, but no new bone is formed by the tumor. As the tumor gradually enlarges, the bone shell may be penetrated and the tumor invade the fascial and muscular tissues. Grossly, the giant-cell tumor consists of a solid, yellowish, light brown or dark material resembling currant jelly, through which are distributed numerous cysts. Microscopically, the tumor is cellular, having many types of cells which do not show signs of malignancy; there are numerous blood vessels, areas of extravasation of blood, and large cells peculiar to this tumor. The giant cells must be differentiated from the other types of giant cells, *i. e.*, the foreign body giant cell found in chronic inflammatory processes and the true tumor giant cell found in very malignant tumors. The derivation of giant cells has been the source of much conjecture, but they probably arise, according to Mallory, from the vascular endothelium. The tumor is undoubtedly derived from cells normally residing in the bone and not from bone-forming cells. It is a tumor evolved within the bone but not of bone or the processes of bone.

Prognosis.—The tumor should be regarded as benign; the prognosis as to life is good and practically all cases should be treated conservatively. When the continuity of the bone is lost from destruction of extensive areas, amputation may be indicated. Central malignant tumors, according to Bloodgood, do not occur under the age of fifteen. Malignancy has been reported but is so rare that it may be almost disregarded. In the past, many limbs affected by giant-cell tumors have been amputated unnecessarily. Incision into the tumor, unless followed by complete excision, often results in development of a fungous growth with infection which is a serious complication. Theoretically,

the limb should be conserved in all cases, for even if malignant degeneration does occur, the danger of death from metastasis is so great that amputation may be useless.

Treatment.—The treatment is surgical and roentgenological. Roentgenotherapy should be administered first, as it has often been successful in arresting the tumor and inducing a sclerosing action upon the bone, but should at all times be under the direction of a competent radiologist. If the roentgen ray is unsuccessful, operative measures are indicated. The tumor should be excised thoroughly, the cavity cureted until all particles are removed and bone chips from the adjacent shaft placed within the cavity; a portion of the wall of the tumor may also be crushed in, but there must be no break in the continuity of the length of the bone. In very large tumors and in those in which there has been gross destruction, such measures may be impossible. When feasible, the tumor and a large area of bone may be excised and the bone grafted successfully. When neither of these measures is possible, amputation may be indicated. Under no circumstances, should an incomplete operation be performed, as secondary infection may result and induce a rapidly growing fungous mass. Many surgeons advocate painting the cavity with carbolic acid, but the author purposely omits the acid as it retards bone production.

Angioma is a tumor derived from and composed of newly formed blood and lymph vessels, but the occurrence in bone is exceedingly rare. The pathology consists of numerous cavernous blood spaces lined with endothelium and filled with blood and blood clots. The roentgenogram demonstrates a tumor closely resembling giant-cell tumor, being central and expansive, but the loculi, or cystic spaces, are much smaller than those of giant-cell tumor. On incision into the tumor the hemorrhage may be so profuse that the operation cannot be continued. Angioma is a benign tumor, and possibly must be considered in the same light in this respect as a giant-cell tumor. Angiosarcoma, or a malignant angioma, has been described, but in all probability such a tumor is in reality an osteogenic sarcoma, with an excessive amount of blood vessels and blood spaces and not a true angioma. Angio-endothelioma is a malignant tumor, recognized by Kolodny as a clinical entity, but as there still exists a difference of opinion among pathologists as to the origin of the cells, this tumor also will be classified as a type of sarcoma. The diagnosis is made by the clinical history of slow onset and symptoms resembling those of a giant-cell tumor. Differentiation from giant-cell tumor cannot be made without biopsy, which, however, is not often necessary except from a scientific stand-

point, as the treatment of choice in both conditions is the roentgen ray. Differentiation of angioma from osteitis fibrosa cystica is made in the same manner as from giant-cell tumor. The malignant tumors with overabundant blood supply may be differentiated by the clinical history, the roentgenogram, and definitely, by biopsy.

Treatment.—Roentgenotherapy should be given under the direction of a competent radiologist. If there is no favorable response, as indicated by condensation of the tumor, by increased density from bone formation, or if there is only partial response, the tumor should be incised and cureted as in giant-cell tumor. After operation, roentgenotherapy should again be given and roentgenograms made at intervals for a period of two years to determine the process of repair. The patient should be cautioned about the probability of recurrence, and instructed to note such signs as pain and enlargement, and to report for observation whenever such signs become apparent. With proper management the prognosis is excellent, but the possibility of an error in diagnosis or of a rare malignant evolution must always be considered, even though malignancy is of rare occurrence.

MALIGNANT BONE TUMORS

Primary malignant tumors arising from the tissues that normally exist within bone may be divided, as are the benign tumors, into those arising from elements that are capable of producing bone, or from cells that are not capable of such differentiation into bone. Those cells capable of producing bone are the primitive or differentiated mesoblast, or the descendants of this mesoblast, the last product in the evolution of this cell being the osteoblast. The cells in bone which are not capable of producing bone, are the myelocytes, the erythrocytes, the endothelial cells lining the blood vessels and the endothelial cells of the perivascular lymph spaces.

Osteogenic sarcoma is a highly malignant tumor. The term "sarcoma" is time-honored and was originally applied to any tumor of firm and fleshy consistency. The term has no relation to the actual structure, and later was applied to bone tumors, possibly because after such tumors pass beyond the confines of the bone and invade the soft tissues, they are of a firm and fleshy consistency. The term is unscientific and does not describe the pathology and should, therefore, be discarded from the nomenclature. It would be far better to regard tumors of bone as osteogenic and nonosteogenic.

Pathology.—Osteogenic sarcoma involves the entire bone, though the terms "central or medullary sarcoma" and "periosteal sarcoma" have

in the past been applied when the lesion was more extensive, respectively, in the medulla or on the surface of the bone. Osteogenic sarcoma is composed of varying elements and cells which are capable of forming bone and other tissues formed in the process of bone growth and bone repair. Therefore, an osteogenic sarcoma is composed of varying proportions of bone, myxomatous tissue, fibrous tissue, cartilage, hyalin, matrix, and blood vessels. Associated with these elements are inflammatory products formed by the reaction on the part of the tissues to the irritation of the growing tumor. These elements are not distributed

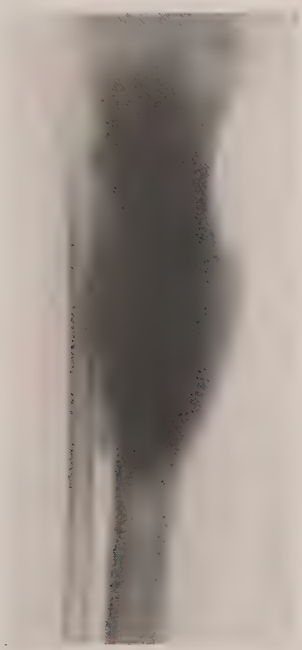


Fig. 378.—Osteogenic sarcoma of tibia with radiating striae from shaft of bone. Anteroposterior view.

Fig. 379.—Same as Fig. 378. Lateral view.

uniformly throughout the tumor, though any one of them may be more or less preponderant. Therefore, it is quite explainable how differences of opinion may arise among competent pathologists regarding sections from the same tumor. For example, a section may be taken from a region in which only cartilage is present, and no elements of malignancy demonstrable; this would indicate to the pathologist that the tumor was a chondroma. A second section might consist largely of normal tissue of an inflammatory or irritative nature, as fibrous tissue or normal bone; another section, myxomatous tissue, and still another, various

types and qualities of cells. There are so many such terms applied to osteogenic sarcoma and so much confusion has arisen from describing neoplasms by the cellular elements observed by the pathologist, that the subject has been rendered incomprehensible. A sarcoma may be osteogenetic, osteoblastic, or sclerosing. These terms are all synonymous and mean that osseous production is present. Osteogenetic and osteogenesis must not be confused with osteogenic, the former indicating actual osseous production, the latter meaning that the tumor is derived from cells capable of producing bone. Bone may or may not be present in an osteogenic tumor. Osteolysis, whether the tumor be benign or malignant, indicates that there is bone destruction caused by the tumor. A telangiectatic sarcoma of bone is one in which there is an overabundant blood supply which may be present to such an extent as to cause pulsation. When a large blood space is formed the term "malignant bone aneurysm" has been employed. Such terms as "myxochondrosarcoma," "osteosarcoma," "round-cell sarcoma" have been applied to denote specific entities, when the same general type of tumor existed. Myxosarcoma is a term employed to indicate a sarcoma in which myxomatous tissue is found in abundance, and will be found described in literature as a clinical entity. A much clearer compre-

Fig. 380.—Osteogenic sarcoma of humerus.

Fig. 381.—Osteogenic sarcoma of femur.

hension of the subject will be obtained if one term, as "osteogenic sarcoma," is employed, and the other terms used solely to describe the microscopical findings in a particular case. The degree of malignancy is determined by the compactness and circumscription of the tumor as indicated by the presence of a capsule, the organization of the cells, and the relative proportion between the cellular and intercellular elements. The stage of the embryological development of the cells is also an index of the degree of malignancy; the greater the reversion to

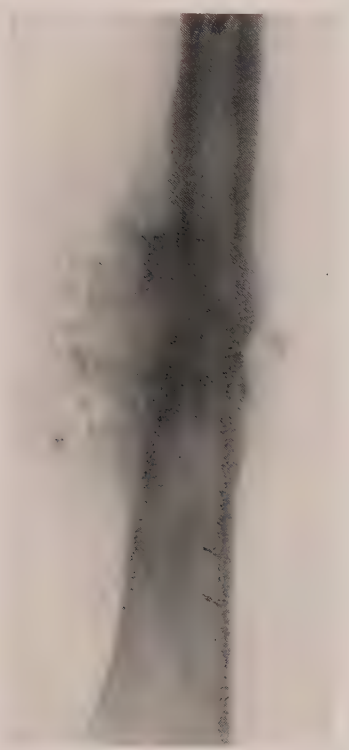


Fig. 382.—Osteogenic sarcoma of lower end of femur with osteolysis and pathologic fracture. Anteroposterior view.

Fig. 383.—Same as Fig. 382. Lateral view.

an embryonic type the more malignant the tumor and the more frequent the metastases. Cell division, metastasis, and formation of chromatin are likewise indicative of malignancy. These factors will be suggestive to a pathologist trained in bone pathology, but even to him there are many opportunities for fallacious conclusions; however, in recent years, the systematization of existing knowledge by the Sarcoma Registry has made pathologic reports more accurate. Osteogenic sarcomas are found in a large percentage in the extremities of the bones

or the metaphysial regions and rarely invade the epiphyses or the joints. The bones most frequently invaded are the femur, the tibia, and the humerus. Skin and articular cartilage are very resistant, and the skin is seldom ulcerated except after incision into the tumor when fungi may develop. Metastases are of the same structure as the primary tumor and occur more frequently in the lungs, though they may invade any organ.

Roentgenoscopy.—The roentgenogram demonstrates various characteristics, which, although not absolutely conclusive, are certainly suggestive. The chief characteristic is that the tumor is more frequently in the metaphysis. It is spindle-shaped, not definitely circumscribed, but the soft structures external to the bone are increased in density

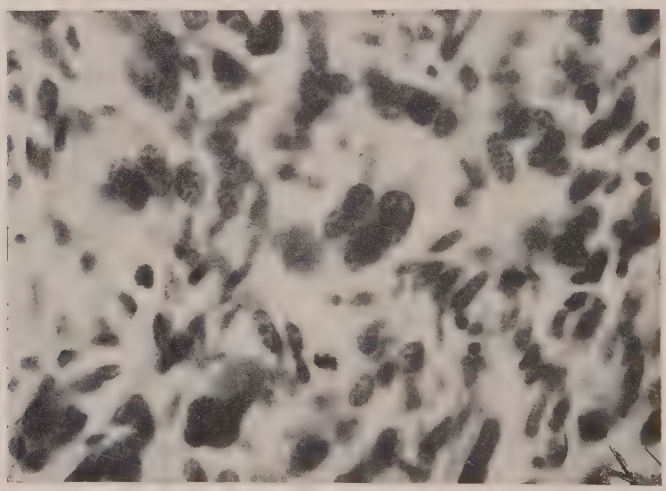


Fig. 384.—Osteogenic sarcoma.

from invasion by the tumor tissue. The shaft of the bone usually remains visible, passing through the tumor. There may be more or less bone production throughout the entire tumor mass in the sclerosing type, which may be structureless, or the bone may be laid down in raylike manner perpendicular to the shaft of the bone. There may be a reaction of the periosteum above the tumor, denoted by proliferation, which may be accentuated when the tumor raises the periosteum from the bone, producing the so-called "lipping." Throughout the affected bone there are often found areas of condensation or opacity. In osteogenic sarcomas, which are osteolytic, there may be partial or complete destruction with extensive tumefaction and invasion of the soft parts, but some of the other characteristics mentioned will be apparent.

The less circumscribed the tumor, the greater is its degree of malignancy. The diagnosis can be made in a large percentage by the roentgenogram alone, but in many, conclusive evidence can be secured only when the roentgenological findings are taken into consideration with the other factors.

Symptoms.—There is often a history of trauma occurring a month or more prior to the onset of the symptoms. The onset is gradual, with constant pain of increasing severity which usually interferes with sleep. The tumor is located on the diaphysis of the bone and the growth is rapid. The size of the tumor is variable, but with present methods, the diagnosis is usually made before large size has been attained. On palpation there will be found a more or less spindle-shaped mass, very tender, with symptoms of intra-osseous pressure, that is, pain which is intensified by continued deep pressure. Movement of the adjacent joint is not affected in the early stage, but as the tumor increases in size, there will be irritation of the muscles causing spasmodic contractures. Pathologic fractures occur, but are not common; union may occur by growth of tumor cells in the sclerosing type or by normal callus. In the early stage, there are usually no constitutional symptoms, but as the lesion progresses there is a profound anemia without cachexia, which is an important point in the differential diagnosis. The pulse rate is accelerated and this increase may be an early manifestation. Local heat is often present but general elevation of temperature is a late symptom. Pain decreases after the periosteum is penetrated by the tumor. Dilatation of the superficial veins may be apparent over rapidly growing tumors. Metastasis may occur to any organ of the body; the lungs are more often invaded and the invasion of the chest can usually be detected by the roentgenogram long before the process can be demonstrated by physical examination. Metastasis of sarcoma is usually produced by invasion of the tumor into the veins with subsequent thrombus formation. In the lungs the growths are usually nodular and appear in the roentgenogram as circumscribed areas of increased density. Pleural effusion may occur and pulmonary symptoms, such as dyspnea and hemoptysis, are late manifestations.

Diagnosis.—Three factors must be taken into consideration in arriving at the diagnosis: the clinical history, the roentgenogram, and the microscopical examination of the tissue excised. The age of incidence is also an important point, as sarcoma occurs usually below the age of forty years and is most common about adolescence when the progress of growth is most active. In many, the diagnosis can be made by a carefully taken history of the onset and symptoms and by the

roentgenogram, though no absolute conclusion can be reached without biopsy. Differentiation from giant-cell tumors is most important, as many limbs have been unnecessarily sacrificed by an erroneous diagnosis. In osteogenic sarcoma, the location is above the epiphysial line and the epiphysis is not often invaded. A giant-cell tumor is rarely on the shaft side of the epiphysis but often involves the epiphysis. Giant-cell tumor is of rare occurrence under the age of fifteen, as are all central involvements of bone by neoplasms—an important point emphasized by Bloodgood. The roentgenogram demonstrates that sarcoma is without definite limits, while giant-cell tumor is an expanded cyst with trabeculae of bone dividing the tumor into compartments, but the cortex is not broken until a late stage of development is reached. Growth of the giant-cell tumor is also very slow and the tumor may have existed for years without apparent symptoms. The local symptoms in sarcoma are intense, while in giant-cell tumor there is slight, if any, pain. Differentiation must be made from myositis ossificans in which the new bone is laid down attached to and parallel with the shaft or in flakes through the muscles; there is very little, if any, pain unless there is pressure on a nerve trunk. Differentiation must also be made from inflammatory lesions and Ewing's tumor. In Ewing's tumor there is a history of intermittent attacks of pain with fever. In osteogenic sarcoma the pain is constant and accentuated at night. Ewing's tumors occur more frequently in the shaft and often more than one bone is invaded. Roentgenotherapy increases pain at first in Ewing's tumor but usually relieves pain in osteogenic sarcoma. Distinction between osteogenic sarcoma and osteochondroma is not difficult if the characteristic manifestations of the roentgenogram are understood.

Treatment.—The treatment of osteogenic sarcoma may be either by amputation or radiotherapy. Local excision is not advisable because of the certainty of recurrence and the probability of instigating metastases to other parts of the body. Amputation should be performed well above the lesion and while it does not prevent the fatal outcome, it does relieve the patient of a painful, and often sloughing and foul-smelling tumor, and allows him to spend his remaining days in comparative comfort. Roentgenotherapy and radium should be employed in all cases, the exposures being given not only to the local area or the stump after amputation, but also to the regional lymph glands and the lungs.

Ewing's Sarcoma (Ewing's Tumor).—A neoplasm in bone, described by Ewing, and known as Ewing's sarcoma, tumor, or endothelioma, presents a syndrome which constitutes a clinical entity. The etiology is

probably the same as that of other tumors, but certain characteristics seem to indicate the possibility of an infectious process. Ewing's tumor

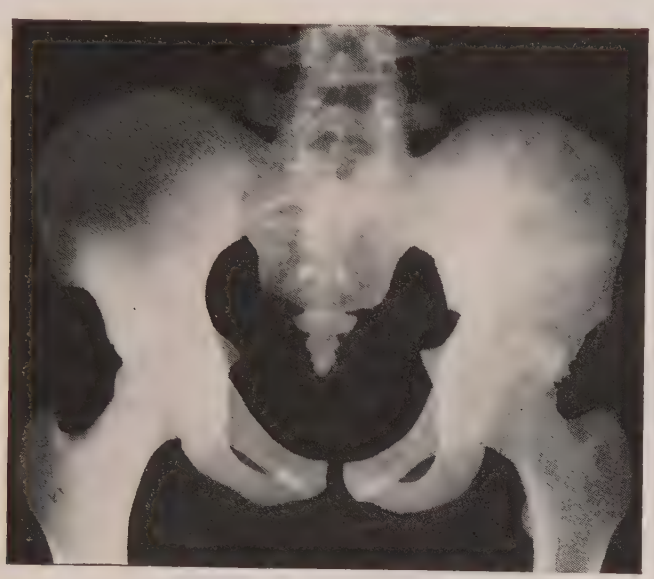


Fig. 385.—Ewing's sarcoma of ilium.

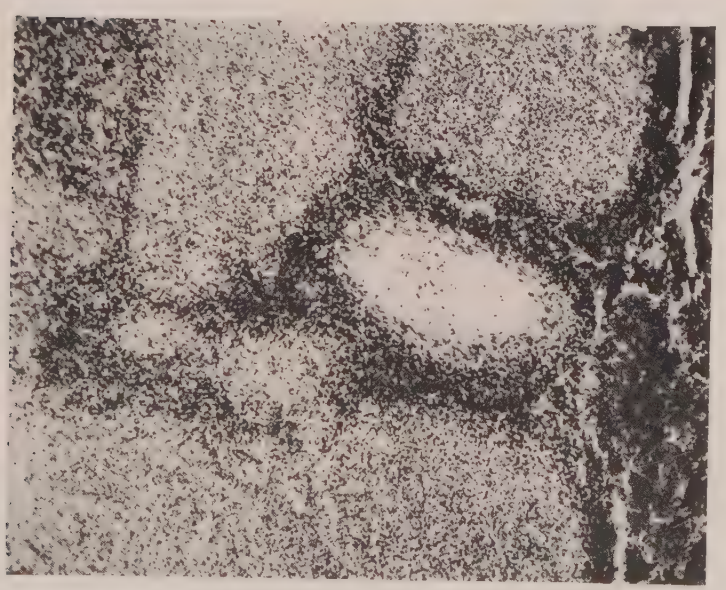


Fig. 386.—Ewing's sarcoma.

is regarded by some as a metastatic lesion of carcinoma. From the records of the Registry of Bone Sarcoma, Ewing's tumor comprises

about 7.5 per cent and osteogenic sarcoma about 92.5 per cent of all malignant tumors in bone. Males are affected more often than females in the proportion of about 3 to 1. The tumor occurs more frequently in childhood and adolescence, being rare above the age of forty. The shafts of the long bones are more often invaded, the most usual location being the tibia, next in frequency in order of occurrence are the fibula, humerus, ulna, and femur. A history of trauma in the affected region

Fig. 387.—Ewing's sarcoma of femur. Anteroposterior view.

Fig. 388.—Same as Fig. 387. Lateral view.

is common and bears the same relation to the etiology as it does in osteogenic sarcoma.

Pathology.—According to Ewing, the tumor is derived from the endothelium or the perivascular lymph spaces, and not from the endothelium of the blood vessels. There is a difference of opinion as to the origin, but it is practically conceded that it is a nonosteogenic neoplasm. The tumor is composed largely of polyhedral cellular ele-

ments, closely packed, with practically no intracellular substance. Many tumors heretofore described in the literature as round-cell sarcoma were probably of this type. The tumor is invasive and causes expansion of the bone by rapid growth. Within the interior living cells are accumulated about the blood vessels; away from the blood vessels there is necrosis with more or less liquefaction and cyst formation. This liquefaction produces a material composed of necrotic cells which grossly resembles pus. The consistency of the tumor depends upon the stage of growth and the degenerative changes within the tumor. No new bone is found within the tumor, but layer after layer may be formed on the surface by the reaction of the periosteum to the tumor growth, which gives the appearance of strata in the peripheral portion of the tumor. As the growth of the tumor progresses, the periosteum is penetrated and later destroyed as the tumor invades the soft structures. Metastasis to other bones is of common occurrence, as is metastasis to the lungs, the pathology of which is the same as that observed in the primary lesion.

Roentgenoscopy.—The roentgenogram demonstrates the gross pathology. The affected bone shows extensive invasion over a large area or of the entire shaft, with longitudinal areas of destruction denoted by striae. The rapid invasion causes expansion of the entire shaft of the bone which is surrounded by longitudinal strata of new bone, deposited in an onion-like arrangement, formed by the reaction of the periosteum. As the process advances, there is extensive destruction and the characteristics of the tumor may be lost. Contrast these manifestations with those of osteogenic sarcoma in which the shaft of the bone is usually of normal shape and size passing through the spindle-shaped tumor mass.

Symptoms.—The growth of the tumor is accompanied by remittent febrile attacks with intermittent pain in the affected bone. In the early stages the attacks subside, but recur with increasing frequency until the symptoms may be more or less constant. A progressive anemia with some cachexia may be observed. On palpation there is an enlargement, often of the entire shaft of the bone with tenderness and signs of intra-osseous pressure, as in osteogenic sarcoma and osteomyelitis; the adjacent lymph glands are frequently enlarged from metastatic invasion. An erroneous diagnosis of osteomyelitis is frequently made, and when the tumor is incised under such a mistaken diagnosis, secondary infection may occur which further complicates the condition and obscures the diagnosis. After such an incision, the symptoms are usually immediately relieved for a time. Later there

will be rapid growth, especially in the soft tissues with morbid tumefaction which indicates the true nature of the lesion. At this time the correct diagnosis has been delayed until even efficient measures offer little hope of recovery. After the institution of roentgenotherapy there is increased pain which lasts a short time, and the favorable response to the roentgen-ray treatment is also a diagnostic sign. As in osteogenic sarcoma, pathologic fractures may occur as a late manifestation. Metastasis to other bone, especially to the skull, is not uncommon, and rarely this may be observed so early that it is impossible to determine the site of the primary tumor.

Diagnosis.—As in sarcoma, the diagnosis can not be made accurately, except by the consideration of three factors: the clinical history, the roentgenogram, and the pathologic examination. Any one of these alone may be suggestive, but as bone reacts in the same manner to different irritations, an osteogenic sarcoma and a Ewing's tumor can not always be distinguished by the roentgenogram. Distinction must always be made between osteomyelitis and Ewing's tumor; as the symptoms of the two conditions bear a very close resemblance this error is almost universal. In Ewing's tumor there is a history of remittent febrile attacks. In osteomyelitis the pain and constitutional symptoms continue for weeks or usually until the pus is evacuated. The white cell count in osteomyelitis is usually much higher than in Ewing's tumor, and there is a relative increase of the neutrophils in osteomyelitis. In Ewing's tumor the relation of the white cells in the differential count is normal. In osteomyelitis culture of the pus shows a pyogenic organism, while in Ewing's tumor the culture remains sterile. However, in this test, there is always a possibility of contamination. In the early stage of osteomyelitis there is no enlargement of the bone; in Ewing's tumor there will be a history of gradual enlargement. Distinction between Ewing's tumor and osteogenic sarcoma in the early stage is suggested usually by the roentgenogram, if the manifestations of both are understood. Also, the recession of Ewing's tumor with increase in pain after the institution of roentgenotherapy is a diagnostic sign. Distinction, of course, must be made between Ewing's tumor and other bone lesions, as syphilis, by similar methods.

Treatment.—Roentgenotherapy or radium treatment in the hands of an experienced radiologist should be instituted when the diagnosis of Ewing's tumor is suggested by the roentgenogram, though there is a difference of opinion as to the relative value of these agents. If the process recedes, the chances are that Ewing's tumor is present and further treatment should be administered. A very small percentage

of cures has apparently been effected by the use of the roentgen ray and radium. Amputation is rarely indicated except for the relief of pain; no other surgical measure except biopsy should be considered. The prognosis in Ewing's tumor is poor, although possibly with earlier diagnosis a larger percentage of cures would be secured. Ewing's tumor is of comparatively longer duration; the patients on an average survive about three years, while in osteogenic sarcoma the average length of life after diagnosis is twenty months.

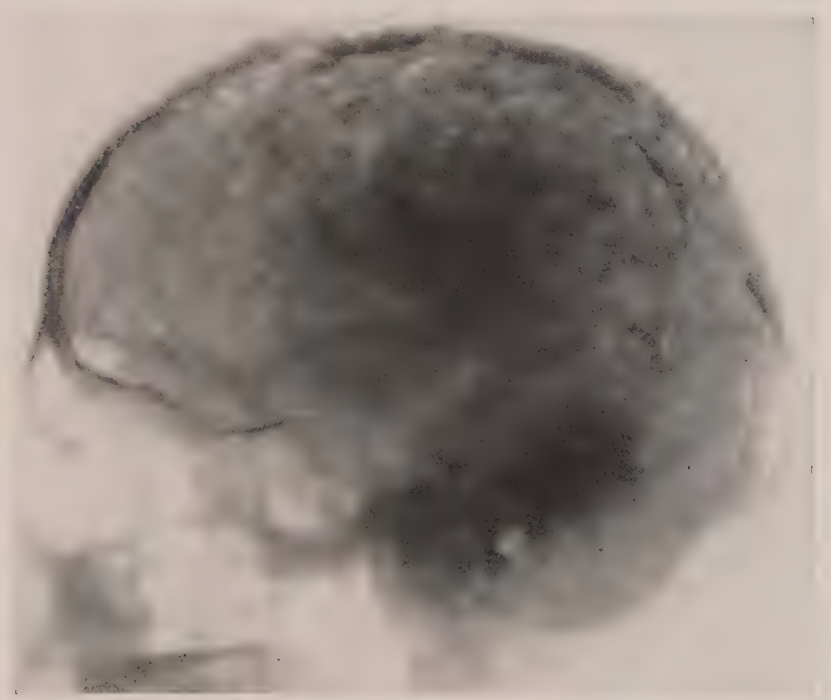


Fig. 389.—Multiple myeloma of skull.

Myeloma is a tumor formed from myelocytes or the cells of the bone marrow. This tumor is of rare occurrence and is often confused with Ewing's tumor, as multiple invasion of bone is common. Metastasis to the lungs does not usually occur, and this fact, when there is involvement of many bones, is the characteristic feature. It is of rare occurrence before the age of forty, and the humerus, femur, and flat bones, as the sternum, ribs, skull, and vertebrae, are more frequently involved.

Pathology.—The tumor is not composed of bone-producing elements, but is driven from the nonosteogenic cells of the bone marrow, of which there are several varieties, the differentiation of which is the problem

of the pathologist. Disseminated nodules are formed in and within the bone, or there may be extensive destruction with the formation of large cysts within the bone. Pathologic fractures are not uncommon as the process advances. Albumosuria and the presence of Bence-Jones proteins in the urine, which have been considered pathognomonic of myeloma, are present only in about 50 per cent of the cases. The roentgenogram demonstrates a mottled appearance of the bone, with well outlined, definitely circumscribed areas of diminished density. The bone may be slightly expanded, the cortex thinned and not uniform in thickness. The cystic areas may be large and single, or small and multiple, in the same bone, spreading over the entire length of the

Fig. 390.—Multiple myeloma of femur with pathologic fracture.

medullary cavity. Solitary cysts are difficult to distinguish from metastatic carcinoma. The roentgenological appearance may be almost identical except that in metastatic carcinoma there is destruction of bone without expansion of the bone cortex. The chief point in diagnosis of myeloma is extensive invasion of the shafts of many bones without metastasis to the lungs.

Symptoms and Treatment.—Pain is a later manifestation than in other malignant bone tumors. A peculiar cachexia and emaciation is prevalent, and also anemia as the process advances. Leukopenia is usually associated but myelocytes and plasma cells in the blood may be increased. The spleen is frequently enlarged and there may be hyperplasia of the regional lymph nodes. The progress of the tumor is slow

and ten or more years may elapse before death ensues. The tumor is favorably affected by roentgenotherapy and radium, though no cures have been reported. In solitary myeloma, amputation may be performed, as life is thought to have been prolonged by this measure. Immobilization may be required when the roentgenogram suggests impending fracture.

Periosteal Fibrosarcoma.—The term "periosteal fibrosarcoma" is objectionable, and the term "periosteal sarcoma" is much more descriptive and preferable, but has been so extensively employed in describing one type of osteogenic sarcoma that it can not be used to designate this particular type of tumor. Periosteal fibrosarcoma is a tumor which arises from the outer layer of the periosteum, is usually extraperiosteal, and is of the same structure as many sarcomas of the soft tissues, that is, composed of spindle-shaped fibroblasts and fibrous tissue. The tumor is of rare occurrence, but may arise at any age. The roentgenogram demonstrates no involvement of bone, except by pressure erosion, but there is increased density in the soft tissues surrounding the bone. The clinical course is similar to sarcoma of the soft tissues and is of much longer duration and less malignant than osteogenic or nonosteogenic tumors within the bone.

Fig. 391.—Periosteal fibrosarcoma after excision.

Treatment.—Roentgenotherapy is of little value. The treatment of choice is complete excision, including the removal of the bone to which it is attached, which usually requires amputation. Partial removal is followed by recurrence with exacerbation of growth and increased malignancy.

METASTATIC BONE TUMORS

Epithelioma may rarely invade the bone by direct continuity from an adjacent skin lesion. This often occurs after chronic ulcer of the leg. The primary lesion in the skin is a carcinoma and the invasion of bone is therefore secondary. Metastasis to bone more frequently occurs from carcinoma than any other tumor, and metastasis from carcinoma of the

breast is by far more frequent than from carcinoma elsewhere. The primary lesion may be so obscure that it is never discovered; it may be located in the intestinal tract and be of an inactive low-grade type and hence escape notice. However, the metastatic growth from such a tumor may be rapidly progressive and swiftly diffused throughout the skeletal system. Metastasis to bone from tumors of the thyroid gland is rare; the diagnosis can be made only by biopsy, or by finding a tumor in the thyroid coincidently with the osseous lesion. Hypernephroma and other malignant tumors as lymphosarcoma may metastasize to bone, but the occurrence in bone is of no material clinical significance, as there is usually diffuse metastasis to other organs, and the

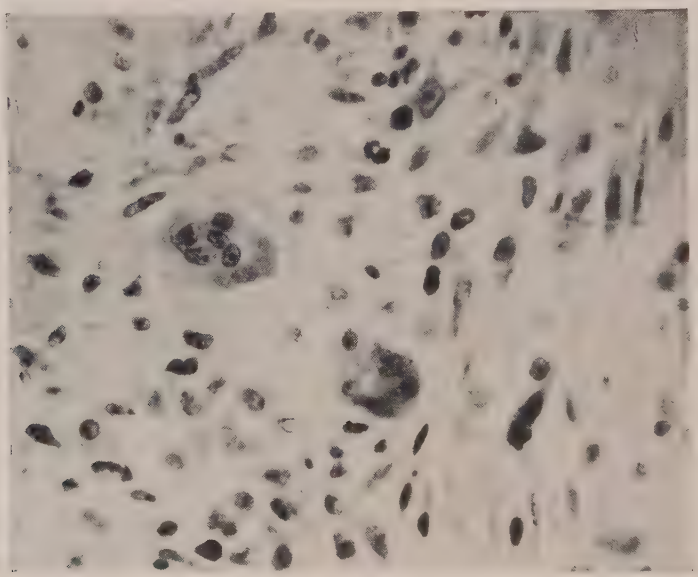


Fig. 392.—Periosteal fibrosarcoma.

diagnosis is made only by biopsy and often only at autopsy. The pathology of carcinoma is not pertinent to the subject of orthopedics but the diagnosis can be easily made by a competent pathologist. The process may be localized at first in one bone, as the vertebra, but usually extends to other portions of the skeleton.

Symptoms.—There may be symptoms of a low-grade type of arthritis when the process is near a joint. When the bone is involved there may be no symptoms except aching in the bone until pathologic fracture occurs. After pathologic fracture the diagnosis is apparent by the roentgenogram. In the spine there is referred pain, muscular spasm, rigidity, etc., which may closely resemble tuberculous spondylitis. A

history of the removal of a breast for cancer is often secured in women and in some instances a tumor may be detected in the breast which has not been discovered previously by the patient. Cachexia may not be present in the early stage, but is always apparent sooner or later. Pathologic fractures from metastatic carcinoma are more frequent in

Fig. 393.—Metastatic carcinoma with pathologic fracture.

the lower extremity than in other parts of the skeleton. These fractures rarely heal by osseous union. The diagnosis is easily made by the history and the roentgenogram.

Roentgenoscopy.—The roentgenogram is characteristic; the lesion of destruction begins centrally but usually becomes diffuse and produces a typical mottled and moth-eaten appearance. The extremity of a bone

is often eroded into the joint, but the opposing articular surface usually remains intact which is a characteristic feature. The entire skeleton may be invaded; in the vertebrae there may be a total collapse without invasion of the intervertebral disk, or in the hip joint, the upper extremity, head and neck of the femur may be destroyed without invasion of the acetabulum. Bone destruction is far more common, but there may be extensive sclerosis, which may be distinguished only with difficulty from the sclerosing type of osteogenic sarcoma. The sclerosis occurs more frequently from primary carcinoma of the prostate gland.

Diagnosis.—Differentiation must be made from myeloma, but the latter condition is rare, and the punched-out areas in myeloma will usually differentiate it. The age of incidence will, as a rule, differentiate carcinomatous metastasis from osteogenic sarcoma and Ewing's sarcoma. Carcinoma occurs more frequently about middle age or in old age, and most often above the age of fifty.

Treatment.—The treatment of epithelioma involving bone consists of amputation which is usually followed by recovery. In metastatic carcinoma roentgenotherapy may give material relief of pain and the patient may remain in comparative comfort for a year or two, but the prognosis is unfavorable and death is inevitable. The prognosis in thyroid metastasis, following roentgenotherapy, with or without excision of the tumor, is better than in other metastatic tumors. Complete recovery may occur without recurrence. Pathologic fractures are treated in the same manner as simple fractures from trauma.

BIBLIOGRAPHY

Barrie, George: Hemorrhagic Osteomyelitis, Surg., Gynec. and Obst., 19: 42, 1914.

Bloodgood, J. C.: Central Sarcoma of Bone, Jour. Bone and Joint Surg., 9: 217, 1927.

Codman, E. A.: Bone Sarcoma: An Interpretation of the Nomenclature, New York, Paul B. Hoeber, Inc., 1925.

Kolodny, Anatole: Bone Sarcoma, Surg., Gynec. and Obst., 44: 163, 1927.

Mallory, F. B.: Giant Cell Sarcoma, Amer. Jour. Med. Res., 24: 463, 1911.

AFFECTIONS OF THE SOFT TISSUES

CHAPTER XIV

AFFECTIONS OF STRUCTURES OTHER THAN BONES AND JOINTS

Deformity may be caused by pathologic changes in the soft tissues surrounding the joints. The skin, the subcutaneous tissue, the muscles, the tendons, the tendon sheaths, and the bursae about the joint may be involved, the etiology, symptoms, and treatment varying in affections of the different structures.

SCAR CONTRACTURES

Wounds which heal by first intention do not, as a rule, produce extensive scars. When the wound heals by granulation the amount of scar tissue which forms is largely dependent upon two factors: first, the extent and depth of the wound and, second, the degree of infection which occurs in the underlying soft tissues. Scar tissue begins to form in a granulating wound about the tenth day. The subsequent contracture of the scar ordinarily serves to hasten the reparative process, but at times the location and extent of the wound make this contracture undesirable. If the area of skin surface lost is small, and located on the back, chest, abdomen or thighs, there is usually sufficient mobility of the surrounding parts to allow the wound to heal satisfactorily. When, however, the wound is near a joint, particularly on the flexor surfaces of such joints as the elbow, knee, wrist, fingers or ankle, contractures frequently result. Through a knowledge of the fundamental principles of joint mechanics and wound healing, many of these deformities can be prevented and milder ones, which have formed, can be corrected without operative procedures. The more severe ones usually require some type of plastic operation.

Etiology and Pathology.—The common causes of scar contracture are (1) burns, (2) lacerated wounds, and (3) infected wounds. Burns may be caused by fire, scalding solutions, chemicals, electricity or excessive friction of the skin surface. First-degree burns are those in which the superficial skin surface only is destroyed, and heal without loss of skin continuity. Second-degree burns consist of a blistering of

the skin and loss of the superficial layers of the epithelium. The deeper layers of the skin with the papillae are preserved and healing follows rapidly if the wound is kept clean and infection avoided. Third-degree burns result from the loss of the entire thickness of the skin with varying amounts of the underlying soft tissues. If the area is extensive, or if small and in an unfavorable location, skin grafting of some type is usually necessary. Lacerated wounds, with direct loss or subsequent sloughing of the skin and superficial tissues, rank second in the causation of scar contractures. The location at which the loss of skin or soft parts occurs determines to a large extent the process of healing and the formation of subsequent contractures. Abscesses in the axilla, the popliteal space, or similar locations, may result in fixed contractures from scar tissue formation. Infections of the hand, particularly those beneath the palmar fascia or those involving the tendon sheaths, may cause stiffness and contracture of the fingers, permanently impairing the function of the hand. Osteomyelitis of the superficial bones, as the tibia or skull, may produce extensive scars which ulcerate from the slightest trauma.

Treatment.—*Preventive.*—Certain definite principles are indicated to prevent the excessive formation of scars. The early removal of necrotic or sloughing tissues, with sterilization of the wound surface, prepares the granulating surface for skin grafting and limits infection in the underlying tissues. Sterilization is best effected by continuous irrigation with Dakin's solution. Extensive burns are successfully treated with medicated paraffin, applied by means of a spray, or in the form of vaselin-impregnated gauze strips. Tannic acid, as suggested by Davidson, is also an excellent dressing for recent burns. The tannic acid precipitates proteins, and when applied to a burned surface in dilute solution, coagulates and precipitates the poisonous materials, prevents their absorption into the body and forms a protective coating over the wound. The burned area is covered with dry sterile gauze pads which are held in place by sterile gauze bandages. This dressing is then saturated with 2.5 per cent aqueous solution of tannic acid. As soon as the part is found to have assumed a light brown color, all dressings are removed. The wound is thereafter left exposed to the air, but is carefully protected from mechanical injury, chilling, and bacterial invasion by a suitable cradle draped with sterile linen.

One of the most essential features of the management of all burn cases is that of maintaining the fluid balance in the body. This is accomplished by forcing fluids by mouth, where possible, or by hypodermoclysis, proctoclysis or intravenous infusions, according to the

special indications in each case. In many lacerated and infected wounds, if the loss of the skin is not too great, the wound can often be sutured secondarily after the surface has been thoroughly sterilized. Covering the raw area of the wound by skin grafts removes both the opportunity and the necessity for the formation of scar tissue. Skin grafting should be employed as early as possible in regions where scar tissue is undesirable. Contiguous granulating surfaces, if allowed to remain in contact, will rapidly become adherent. Surfaces, such as those of the axilla and popliteal space should be kept well separated during the process of healing. Many contracture deformities can be prevented by proper splinting during this period. The process of scar formation is often not complete for months after the wound has healed, and the utmost care must be exercised not to remove the splint too early. Certain well recognized rules in regard to splinting are fundamental. In wounds of the front of the ankle, the foot should be in plantar-flexion; when the region of the tendo achillis is involved, the foot should be at a right angle. In infection or wounds around the popliteal space, the knee should be held in full extension. A posterior splint extending well up the thigh and down to the foot can be used until the wound is healed, when a walking-brace with a kneecap may be substituted during the day and the splint reapplied at night. Many contractures occur because the use of a splint at night is overlooked. Wounds on the flexor surface of the hip should be treated with extension and abduction. In infections or burns about the axilla, the arm should be kept well abducted. It is not uncommon, following extensive burns, to see the axilla obliterated and the arm adherent to the chest as far down as the elbow. In wounds at the bend of the elbow, the arm should be kept in full extension. In wounds on the flexor surface of the wrist, the hand should be held in dorsiflexion. This can be done by a splint applied either on the back or front of the joint. With infections of the hand, the position of function should be maintained at all times. This position is slight dorsiflexion of the wrist, slight flexion, about 20 degrees, of the metacarpophalangeal joints, and abduction of the thumb with almost full extension. A hand with hyperextended metacarpophalangeal joints and a thumb drawn in against the palm is useless.

Treatment of Contracture.—Contractures resulting from the formation of scar tissue vary in severity from mild scars to extremely resistant deformities. The treatment of the contracture may be mechanical or operative. In many cases, a combination of both mechanical and operative methods is necessary.

Mechanical Treatment.—Many deformities may be completely and

permanently corrected by gradual stretching of the scar. The methods of such correction and the apparatus employed are similar to those described for the correction of other deformities of the joints in Chapter II. Forcible stretching, under anesthesia, is rarely advisable, and when attempted, only a moderate degree of force should be used. Manipulation usually causes a reaction which is followed by an increased amount of scar formation resulting in further contracture. Serious injury by crushing of the articular surfaces of the bones may also result from overstrenuous manipulations.

Surgical Treatment.—Operative treatment consists of the complete removal of the scar and replacement by normal tissue. The dissection should be sufficiently extensive to expose healthy tissue throughout the wound, and the resulting raw area should be covered by an appropriate type of skin graft. Autografts are transplants from the patient's own body and should always be used when possible. Isografts are those removed from other individuals. As a rule, they are not satisfactory, most of them failing to take, and those which do take often gradually disintegrate. Satisfactory results have been obtained occasionally when the proper precautions were employed. The donor and recipient should be grouped, as in blood transfusions, or failure is certain to result. Zoografts are grafts transplanted from animals to human beings. Occasional successes have been reported, but it has been the experience of most surgeons, even though an initial take is secured, that the grafts are eventually absorbed. When operating in and around scars, it should always be remembered that the vitality of scar tissue is very low, the blood supply poor, and that the slightest disturbance of nutrition will result in sloughing.

Reverdin Grafts.—Reverdin grafts are sections of skin about 1 cm. in diameter and consisting of the epidermis and a small amount of dermis. They are useful for covering even large areas where only the skin has been lost or where there is a sufficient amount of soft tissue beneath. They are best removed under a local anesthetic by inserting the tip of a small needle into the epidermis, raising a small cone of skin and cutting it with a scalpel. The grafts are placed upon the area to be grafted about $\frac{1}{2}$ cm. apart. On healthy granulating surfaces, almost 100 per cent success may be expected.

Ollier-Thiersch Grafts.—Ollier-Thiersch grafts are much larger than Reverdin grafts, often being several inches in each dimension, but they include only the upper layer of the corium. They are particularly suitable for covering large fresh operative wounds where it is not necessary to supply any soft tissue.

Whole Thickness Grafts (Wolfe-Krause).—Whole thickness skin grafts include the whole thickness of the skin and a small amount of the underlying fat. They may be of almost any size desired, but an ellipse of about 2 x $\frac{3}{4}$ inches has proved most satisfactory. The fat is entirely removed by a scalpel before the graft is applied. The area to be grafted must be thoroughly aseptic and free from blood clots. It may be a granulating area or a fresh wound. The advantage of these grafts is that they cover large areas without the formation of any scar and that they supply the whole skin thickness.

Pedunculated Skin Flaps.—The pedunculated skin flap is the method of choice, when it is necessary not only to cover a large skin defect,

Fig. 394.—Pedicled tube of skin from right abdominal and chest wall for transplantation to axilla.

but also to supply enough healthy soft tissue to permit mobility and stretching. A two-stage operation is required, as the flap can not be completely severed from its original site until it has become sufficiently attached in its new location to insure its blood supply. The flap includes the whole thickness of the skin and subcutaneous fat down to the fascia. If a graft only 2 or 3 inches in length is desired, the flap may be dissected up the desired length, one end cut free and sutured directly into the area to be covered. After ten days or two weeks the remaining pedicle may be gradually divided under local anesthesia, cutting about one

third of the pedicle on succeeding days. If a very large flap is to be used, both ends should be left attached for a time to prevent sloughing and to allow the development of an increased blood supply through the pedicles. The free margins of the flap are sutured immediately to form a tube. After two weeks one end is cut loose and the flap transplanted in the usual manner. Variations of this technic may be used when the part to be covered can be brought directly under the flap and a primary suture effected, as in passing the hand under a flap from the abdominal wall. The graft may be transposed from one part of the body to another, allowing it to attach at one or more places before finally reaching its permanent location. A flap may thus be transferred from the thigh to the axilla.

Fig. 395.—Following operation for scar contracture of axilla.

Treatment of Special Deformities.—Before operating on bones or joints over which there is an adherent scar, it is usually advisable to do a preliminary operation removing the scar and filling the defect with normal skin, otherwise sloughing of the scar may expose the operative field and cause serious infection.

Scars Over the Heel and Ball of the Foot.—These scars are usually due to pressure sores or to traumatic injuries or burns, or are trophic ulcers seen in diabetes, tabes, spina bifida, etc. When painful enough to interfere with walking, they should be excised and the defect filled with a pedicle graft.

Scars Over the Tibia.—Adherent scars over the tibia are quite common following osteomyelitis, compound fractures, burns, and lacerations of the soft parts. These scars become firmly attached to the

underlying bone, their nutrition is poor, and they are in a location which is constantly subjected to injury. Slight trauma causes a sloughing and ulceration which is difficult to heal. The only satisfactory method of treatment is complete removal of the adherent scar and the shifting over of the adjacent normal skin. If normal skin on the same leg is not available, a pedunculated flap from the opposite thigh may be used instead. Shifting of the adjacent skin by the following method has been used in a large number of cases with excellent results. The entire scar is dissected from the bone and the thickened bone over the front of the tibia is chiseled off. A second incision, usually about 2 inches to the inner side of the calf, is made parallel to the wound and

Fig. 396.—Technic and result of plastic procedure for ulcer of leg following osteomyelitis.

the skin and subcutaneous fat dissected, making a flap attached at both ends. This flap is displaced outward to cover the raw area over the tibia and sutured firmly to the lateral skin edge, completely covering the exposed bone. The raw area on the inside of the calf from which the flap was removed is allowed to heal by granulation or may be covered with small, deep grafts. When the scar is long, extending the full length of the tibia, two flaps are used, one from the inner side to cover the upper half and one from the outer side to cover the lower half of the defect.

Scars Involving the Knee.—The deformity of the knee is usually a flexion contracture and is due to infection in the popliteal space or

burns involving the thigh and leg. Most of these affections can be corrected by mechanical means, as the leverage on the joint is great and the amount of surrounding soft tissue sufficient to allow considerable stretching. Simple traction on the leg, as by Buck's extension, rarely accomplishes the desired result. Correction is best secured by a specially designed extension apparatus. Even very resistant deformities can be corrected in four to eight weeks' time. Correction by successive plaster casts, which are cut at the knee and gradually wedged apart is a slow but always available method. When correction can not be obtained by apparatus alone, removal of the scar, tenotomies and fasciotomies of the contracted soft tissues and transplantation of healthy skin must be done. Careful after-treatment to prevent recurrence of the deformity should follow either method. During the day, walking-braces extending well above the knee must be worn and at night a straight posterior splint must be applied for several months.

Arm-chest Adhesions.—When the axilla has been obliterated and the arm bound down to the chest by adhesions and scar formation, no mechanical stretching is of any benefit and operation offers the only hope of relief. The essential point in the operation is to place sufficient healthy skin in the axilla to allow abduction of the arm. If the skin over the chest and back is not destroyed, flaps may be shifted from their locations after the arm has been freed and the scar tissue removed from the axilla. When there is no normal skin in the vicinity of the axilla, a flap must be brought from some other area.

Contractures About the Elbow.—Contractures of the elbow, as those about the knee, usually occur in the flexed position. The same principles of treatment are applicable, surgical procedures and apparatus being modified to suit the location.

Contractures of the Wrist, Hand, and Fingers.—Disabling scars about the wrist are usually on the anterior surface and are accompanied by contractures and adhesions of the flexor tendons, resulting in flexion deformity of the wrist and fingers. If the scar is not too deep or extensive, a useful hand can often be secured by gradual extension on a splint, accompanied by massage and baking. A combination malleable cock-up splint with banjo attachment for traction on the fingers has been found most useful. The splint is applied in the position of deformity, the fingers gradually drawn out by attached rubber bands, and dorsiflexion of the wrist is then begun, bending the splint up each day as the deformity is corrected. Progress is often very slow, due to swelling and pain throughout the hand. The splint may be removed each day for physiotherapy, if this is available. After the deformity is

well corrected in both fingers and wrist, the finger extension may be gradually discontinued and active function encouraged, leaving the cock-up splint on the wrist. Support in the corrected position should be maintained until all tendency to recurrence has passed, this often being months after correction has been accomplished.

When the metacarpophalangeal joints are hyperextended and the thumb adducted against the palm, which so often follows infections of the hand, the same type of splint may be used, but the pull made to flex the fingers and to abduct the thumb. When the scar is too dense and adherent to permit stretching by mechanical means, a plastic operation with removal of the scar and transplantation of a pedicled flap will be necessary. Scars of even moderate severity involving the palm of the hand and fingers usually require excision and transplantation of skin to insure sufficient mobility for good use of the hand. Simple excision is usually a failure as the scars re-form. Removal of a wedge-shaped area from the carpal bones is occasionally required to correct the flexion deformity when the condition has persisted for many years.

Fig. 397.—Scar contracture of hands, neck, and face.

Dupuytren's Contraction.—Contraction of the palmar fascia, causing progressive deformity of the fingers and hand, is known as Dupuytren's contraction. Males are affected more often than females; the fourth and fifth fingers are usually involved and the condition is frequently bilateral.

Etiology.—The cause is still unknown. Trauma, focal infection, metallic poisoning, constitutional disease, congenital malformation, neurological condition, and glandular deficiency have all been suggested as etiologic factors. Heredity undoubtedly has a decided influence in the occurrence of the contraction, as the deformity is often seen in successive generations in one family.

Pathology.—The palmar fascia becomes hypertrophied and contracted. The process begins as a nodular thickening, most frequently over the flexor tendon of the ring finger. As the disease progresses, similar nodules appear in line with the first or over the flexor tendons of

the little finger, middle finger or index finger. The fibrosis involves not only the superficial palmar fascia, but also the interfascial septa which unite the superficial fascia with the volar interosseous fascia and occasionally the dorsal fascia. As the process advances, the overlying skin becomes affected and a dense fibrous cord is formed. The flexor tendons and their sheaths remain normal. After varying intervals, the finger is gradually contracted, the metacarpophalangeal joint and the proximal interphalangeal joint being flexed while the distal joint is extended. Eventually the tip of the finger may lie upon or press into the surface of the palm.

Symptoms and Diagnosis.—The affection occurs most frequently in men over forty years of age. Subjective symptoms are rarely present, but some patients complain of slight pain and tenderness in the fingers and palm. The deformity develops gradually, producing contracture

Fig. 398.—Dupuytren's contracture.

of the fourth finger and less often the fifth and third fingers. The powers of flexion and extension of the joints is retained, except as they are limited by the contraction of the soft tissues. Function may be normal until the fingers are firmly contracted against the palm. The condition must be differentiated from flexion of the fingers produced by contraction of the tendons and tendon sheaths, from burns, spastic paralysis, and congenital anomalies. A careful history of the onset, duration and progression of the condition will usually be sufficient.

Treatment.—The treatment consists of excision of the contracted structures. An incision is made in the palm, either longitudinally or transversely in line with the distal flexion crease, as suggested by Kanavel. The skin is dissected, freed from adhesions and raised over a sufficient area to expose the contracted portion of the palmar fascia. The fascia is separated from its deep attachments and excised from the

highest possible level, approximately on a level with the outstretched thumb to the base of the fingers. The wound is closed without tension, using skin grafts, if necessary, to repair the defect, and the affected fingers are immobilized in extension for about ten days. Active use is encouraged as soon as possible which is aided by physiotherapy.

INJURIES OF THE MUSCLES

Rupture of Muscles.—Muscles may be ruptured by violent contractions, by sudden elongation of a contracted muscle, or by contusion of a contracted muscle. The muscles usually affected are the extensor brevis of the toes, the gastrocnemius, the plantaris, the tibialis posticus, the rectus femoris, the biceps femoris, the adductors, the pectoralis major, the biceps cubiti, the deltoid, the trapezium, the sternomastoid, or the abdominal muscles.

Pathology.—The tear usually occurs at the attachment of the muscle belly to its tendon. It may be complete, partial, or fibrillar, in which only a few fibers are torn. A hematoma forms, which is gradually absorbed, and the gap replaced by scar tissue. Muscle tissue does not regenerate; consequently, when muscle fibers are destroyed, they are replaced by fibrous connective tissue, fat and, at times, bone. The contractile function of the muscle is thus diminished, and, as the fibrous tissue contracts, motion of the joint may be limited and deformity occur.

Symptoms and Diagnosis.—At the time of the injury or during an unusually violent movement, the patient feels a sudden sharp pain which is accompanied by the sensation of "something giving way"; in some instances, an audible snap may be heard. The part is painful on movement, swollen and the skin becomes ecchymotic at the point of rupture. A gap may be palpable in the substance of the muscle, and if the rupture is complete, the corresponding movement of the joint may be lost. The diagnosis is made from the history and the symptoms. A roentgenogram may be necessary to exclude fracture.

Treatment.—In the incomplete variety, the treatment consists of immobilization in a position to relax the affected muscle. If the rupture is complete, immediate suture is indicated, followed by immobilization and physiotherapy.

INFLAMMATION OF THE MUSCLES

Acute inflammation of a muscle may occur during the course of an acute infectious disease, as typhoid fever or scarlet fever; a low-grade inflammatory process may occur in tuberculosis and syphilis. The pathology and clinical course of such infections do not differ materially

from those of similar affections elsewhere in the body. The treatment is immobilization to prevent contracture deformities with appropriate measures for the eradication of the systemic infection. Two forms of low-grade inflammation in muscles require special consideration. These are ischemic myositis and myositis ossificans.

Fig. 399.—Contracture of hand following ischemic myositis.

Ischemic myositis (Volkmann's paralysis) is the result of progressive degeneration and death of the muscle fibers (necrobiosis). The cause is an obstruction of the arterial and venous circulation in the extremity. The muscle tissue is replaced by fibrous tissue and characteristic paralysis and deformity result.

Fig. 400.—Contracture of foot following ischemic myositis caused by prolonged application of tourniquet after snake bite.

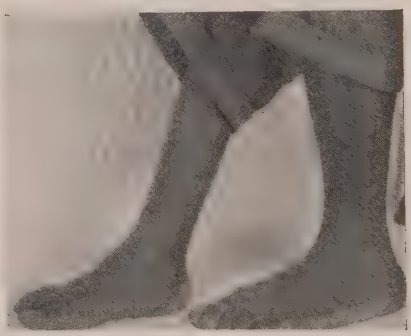


Fig. 401.—Same as Fig. 400. After operative correction.

Etiology.—Ischemic paralysis usually involves the muscles of the forearm, but the lower extremity may rarely be affected. It occurs most often between the ages of four and twelve years, following fractures in the region of the elbow joint. Undoubtedly the most frequent cause is constriction of the arm by splints that have been too tightly

applied, or which have become too tight from subsequent swelling of the arm. However, the deformity has been known to follow fracture of the arm when no dressing has been applied. In these cases the obstruction to the circulation has been assumed to be pressure of the fragments on the brachial artery; intense swelling of the extremity may also result in the skin and deep fascia becoming tense and compressing the underlying muscles. Severe contusion without fracture and the prolonged use of a tourniquet are other well known causes. The damage occurs in a very short time; if the arterial flow is arrested for three to six hours, myositis will usually develop in the extremity below the obstruction.

Pathology.—The muscles on the flexor surface and ulnar side of the the forearm sustain the greatest injury. Following the edema and swelling, the muscles degenerate. Infiltration with small round cells occurs and the muscle is replaced by fibrous connective tissue. The muscles are matted together in a dense scar, and as contraction develops, the wrist and fingers become flexed. The nerves may also be affected, but the nerve symptoms are usually late and appear to be due more to constriction of the nerve by scar tissue than to the primary anemia.

Symptoms.—During the stage of onset the symptoms are intense pain, swelling, cyanosis or blanching of the finger tips, loss of motion and sensation. If the cardinal symptoms of constriction, discussed in Chapter III, are kept in mind many serious complications will be avoided. After constriction has occurred, the arm is edematous; the skin is covered with blebs and there may be areas of pressure necrosis at the point of greatest constriction (usually just below the elbow). The muscles feel hard and swollen and the child can not move his fingers. Later, the typical deformity is a clawhand; the elbow is flexed, the forearm pronated, the wrist flexed, the metacarpophalangeal joints extended, and the interphalangeal joints flexed. The thumb is usually adducted under the palm. The surface temperature of the hand is lowered; the skin is thin, shiny, and may show trophic ulcers at the tips of the fourth and fifth fingers. Sensation in the hand may be diminished. The flexor muscles of the forearm are hard, boardlike in consistency and the tendons stand out prominently on attempt to straighten the wrist and fingers. Active motion in both flexion and extension is greatly diminished or entirely absent. Passive movement of the joints is usually normal; the fingers can be extended when the wrist is flexed, and the wrists can be extended when the fingers are flexed.

Diagnosis.—The diagnosis of ischemic paralysis is usually made

from the history of sudden onset following a fracture or other injury. The symptoms and appearance are characteristic; the boardlike feel of the muscles is almost pathognomonic. Other conditions with which it might be confused are spastic paralysis, obstetrical paralysis, and anterior poliomyelitis. Spastic paralysis and obstetrical paralysis are distinguished by the duration of the affection since birth. Anterior poliomyelitis is to be differentiated by the flaccid character of the paralysis.

Prognosis.—The prognosis is always unfavorable. The milder cases, when seen early, may be greatly benefited, but generally there is a permanent impairment of function in the extremity.

Treatment.—Preventive Treatment.—The most efficacious form of treatment is, of course, the preventive. Great caution is required in the application of circular dressings to the forearms of children after trauma. The acutely flexed position universally employed in the treatment of fractures about the elbow is particularly dangerous. The limb must be inspected frequently during the first forty-eight hours. If undue pain or other cardinal symptoms of constriction are present, the dressings must be removed, the arm massaged, the joints passively moved, and the dressings loosely reapplied. This inspection may be repeated every two hours, and if the manipulation is too painful, an anesthetic may be administered. If, in the opinion of the surgeon, the arrest of the circulation is due to pressure on the brachial artery, the position of the fragments may be changed by careful manipulation. When the constriction is due to edema of the structures below the deep fascia, multiple incisions through the skin and deep fascia down to the muscles may relieve the tension.

Corrective Treatment.—The corrective treatment consists of gradual extension of the contracted structures. Since the distal joints can usually be straightened when the proximal ones are flexed, a metal splint is applied to hold the interphalangeal joints in extension while the metacarpophalangeal joints and wrist joint are flexed. The splint is changed daily and bent so that the metacarpophalangeal joints are gradually straightened. When the fingers become straight, the wrist is gradually extended in the same manner until it can be hyperextended. Physiotherapy is of great value and should include baking, hot-water baths, massage, and active and passive exercises. Surgery offers little hope of improved function. The plastic lengthening of the muscles is perhaps the most rational procedure of the various operations which have been advised. Resection of a portion of the shafts of the radius and ulna has been employed but is rarely necessary.

Myositis ossificans is a low-grade inflammatory process characterized by the formation of bone within or in contact with a muscle. Three types of the disease are described: (1) The progressive; (2) the circumscribed; and (3) the traumatic.

Etiology.—The actual cause of the condition is not known. Various theories have been advanced, the most important of which are: (*a*) Implantation of periosteum into a muscle; (*b*) escape of osteogenetic cells from the periosteum; (*c*) ossifying hematoma; and (*d*) metaplasia. Males are affected more frequently than females, and trauma plays an important rôle in almost every case. Progressive myositis usually begins in the muscles of the back and steadily involves all the muscles

Fig. 402.—Traumatic myositis ossificans.

of the body. Death occurs finally from interference with respiration. In the circumscribed and traumatic forms, the bone production is limited to a single muscle. Repeated mild injuries may cause irritation in a muscle which leads to the formation of circumscribed areas of calcification. The brachialis anticus muscle is most often affected. Other common sites are the quadriceps muscle, the adductors and the biceps brachii. In the circumscribed form, the onset is slow, but in the traumatic form, after acute injury the muscles may rapidly undergo ossification. The entire process in traumatic myositis ossificans may occur in three months. Dislocation of the elbow is the most common predisposing factor. Bone may also form in muscle following fractures, muscle contusions, and muscle rupture.

Pathology.—Specimens removed at operation show degeneration of the muscle fibers, replacement by fibrous tissue, cartilage cells, and normal appearing bone. There may or may not be an attachment of the bony mass to the skeleton. The arrangement of the osseous structure is usually a flattened mass when located on the surface of the muscle and a rounded or oval mass in the depth of the muscle.

Symptoms.—The symptoms are those of interference with muscular function. Pain is rarely a prominent symptom. The mass may be palpable and gradually becomes larger and firmer. The roentgenogram reveals a shadow in the muscle, which becomes gradually denser until the appearance is similar to that of normal bone.

Diagnosis.—The diagnosis is made by the history of the injury, the progressive limitation of motion in a joint, palpation of the bony mass, and the roentgenogram.

Treatment of the circumscribed and traumatic varieties is entirely surgical. As there is a tendency toward recurrence, if excision is not complete, operation should be deferred until ossification has ceased. The roentgenogram should be repeated at intervals and when no further bone formation is apparent, wide excision should be performed. In the progressive form no treatment will delay the fatal termination.

INJURIES OF THE TENDONS

Violent muscular contraction may rupture a tendon or separate it from its insertion. Lacerating wounds and severe contusions may also divide one or more tendons. Lacerating wounds of the volar and dorsal surfaces of the wrist which sever the flexor or extensor tendons of the hand and fingers are particularly disabling. The symptoms and treatment of such lesions are identical with rupture of the muscles. When a tendon which is essential to good function is divided, an immediate operation is indicated with identification and approximation of the ends and repair by silk or linen sutures.

Displacement of Peroneal Tendons.—Tendons may also be dislocated from their anatomical positions. The peroneal tendons are most frequently dislocated, being displaced forward from their normal position behind the external malleolus. The cause may be traumatic, or due to congenital malformations of the groove in which the tendons lie. A similar dislocation is also seen in paralytic flatfoot. The displacement occurs when the foot is dorsiflexed and abducted. The symptoms are local swelling and ecchymosis. Function of the foot is not seriously impaired. The treatment consists of replacing the tendons in their groove; they may be held in position by maintaining the foot

in dorsiflexion and inversion. Recurrence of the dislocation may result, in which case, open operation may be necessary. An artificial groove can be constructed by turning up an osteoperiosteal flap from the fibula and suturing it about the tendons after they have been replaced into the normal position.

Tenosynovitis.—The tendons and the tendon sheaths may be involved in inflammatory processes. Tenosynovitis occurs most frequently in the tendon sheaths of the wrist and ankle. Because of their intimate association, the inflammation usually involves both the tendon and its sheath coincidentally. Any of the classical types of inflammation may occur, as plastic, serous, purulent or proliferative. The tendon sheath is thickened. The synovial fluid is increased and may be normal in character, serous or purulent, depending upon the nature of the infecting organism. Tuberculosis is often the causative agent and in tuberculous tenosynovitis, rice-body formation is frequently seen. The symptoms are swelling, pain, and often crepitation on motion, and impairment of function. The diagnosis is easily made, but the condition must be differentiated from arthritis and mild traumatic affections. The treatment consists of rest with immobilization of the joint, aspiration of the fluid and excision of the thickened synovial sheath when the condition persists or recurs.

Ganglion.—A ganglion is a cyst which is developed from the synovial membrane of the tendon sheath or joint. Ganglia are situated generally on the dorsum of the wrist and contain a clear colloid material. They appear gradually and are usually associated with a slight strain about the joint. The small tumor mass does not move with the tendon, but becomes tense when the tendon is stretched, those on the dorsum of the wrist being prominent when the wrist and fingers are flexed. The chief symptom is pain which is mild in degree but may persist indefinitely. If the ganglion is not painful, no treatment is necessary. Rupturing the ganglion by striking it with a blunt instrument as the corner of a book is to be condemned. Aspiration of the colloid material has been advised and following the aspiration a few drops of tincture of iodine, phenol or 1 per cent mercurochrome may be injected to produce a slight inflammatory reaction with obliteration of the cyst cavity. Such injection, however, may be followed by a severe reaction, especially if the ganglion communicates with the joint cavity. If pain is severe, surgical excision should be performed. Recurrence is frequent unless the entire sac is removed.

Trigger finger is a condition caused by a stenosing tenovaginitis of the flexor tendons of the finger. When the fist is closed the affected

finger becomes caught in the flexed position and remains closed after the other fingers are extended. When the digit is passively extended there is a slight resistance until the movement passes a certain point, after which the motion is free. The right hand is more frequently involved than the left and the women are more frequently affected than men. The middle finger is more commonly involved; the ring finger and thumb are next in frequency and the index and little fingers are seldom affected. According to Kroh, the site of the lesion is not at the interphalangeal joint as is commonly supposed, but at the level of the metacarpophalangeal joint where the tendon sheath is physiologically narrowed by the accessory volar ligament. The obstruction may be caused by a circumscribed thickening of the tendon while the sheath is normal or by a thickening of the sheath. The treatment consists of immobilization of the finger in extension and physiotherapy. In resistant cases excision of a portion of the tendon sheath on the volar aspect may be necessary.

BURSITIS

Bursae are sacs over the bony prominences usually located around joints, or at some point where a tendon or muscle moves over a projecting portion of bone. They are lined by an endothelial membrane and may or may not communicate with the joint cavity. The function of bursae is to lubricate and protect the more delicate structures from pressure. Some of them, as prepatellar and olecranon bursae, are constantly present, while others, such as the bursae over bunions and over the kyphos in a tuberculous spine, develop only as a result of constant irritation. The importance of the numerous bursae of the body as a location of disease and cause of many obscure disabilities is becoming more universally recognized. This is due to a clearer understanding of their physiologic functions and to a better knowledge of the various pathologic changes to which they are subject.

Classification.—Being anatomically and physiologically similar to tendon sheaths and the synovial membrane of joints, bursae are subject to diseases of similar type, which may be classified as follows: (1) Traumatic: acute, chronic; (2) infectious: acute, chronic; (3) syphilitic; (4) gouty.

Traumatic Bursitis.—A blow directly over a bursa may produce an effusion, usually serous, which appears rapidly and gradually subsides as the fluid is absorbed by the lining cells. Repeated trauma of a minor nature, as the rubbing of a shoe over the heel, or the performance of an unusual exercise, such as painting over one's head, may also produce an acute bursitis. The chronic type of traumatic bursitis is by far the

more common, as repeated minor trauma to a bursa gradually produces such thickening of the walls and degeneration of the lining cells, that the secreted fluid is no longer absorbed and the sac becomes greatly distended. The typical prepatellar bursitis, or housemaid's knee, is an example of this type. Bursae, not normally present, but which develop in response to unusual friction over bony prominences, are traumatic in origin. As a rule, they do not cause symptoms unless secondarily infected.

Infectious Bursitis.—The infectious type of bursitis is similar in its etiology and classification to arthritis. The etiology may be one of the acute pyogenic organisms, or an attenuated low-grade type of bacteria. The acute form may be suppurative or nonsuppurative, depending upon the type and virulence of the infecting organism. The organism may gain entrance into the bursa by direct puncture from without, by extension from nearby infection, or by metastasis from a distant focus. The chronic infectious type is the most common and is generally associated at its incipiency with a traumatic irritation of the bursa. The absorption of bacteria or their toxins from the common foci of infection, such as abscessed teeth, or infections of the tonsils or sinuses, is the underlying cause of the bursitis in many cases. Chronic gonorrhea with latent foci in the prostate and seminal vesicles is also a common origin of the infection. Typical tuberculous bursitis, with the production of rice bodies, is occasionally seen.

Syphilitic Bursitis.—Syphilis has been definitely proved to be the causative agent in a number of cases of bursitis. Verneuil first described the condition in 1868. The prepatellar bursa is the common site for syphilitic infections and the acromial and olecranon bursae may also be affected. The bursitis usually occurs during the tertiary stage of syphilis and is characterized by a primary effusion into the bursa, which later has a tendency to break down, forming sinuses or areas of ulceration. The incidence of syphilis in connection with bursitis is sufficiently frequent to warrant an examination of the blood in all chronic cases. When the Wassermann test is positive, thorough antisyphilitic treatment should be employed before surgical measures are advised. In some cases where the bursa has become irreparably damaged, or where secondary infection has occurred, removal of the bursa will be necessary in addition to the antiluetic treatment.

Gouty Bursitis.—Degenerative changes in the bursae associated with metabolic diseases, such as gout, sometimes occur. The condition is characterized by chronic inflammatory changes in the bursal walls, and is accompanied by distention of the bursa with chalky deposits in

the tissues. The olecranon bursa and the prepatellar bursa are more frequently involved.

Pathology.—The walls of bursae are composed of fibrous tissue, lined with a layer of cells similar to the synovial membrane covering the tendons, and are normally filled with a small amount of clear fluid resembling synovia. Some bursae, such as the subscapular, connect directly with the joint near which they are situated, but the majority are completely closed sacs, distinct and separate from the neighboring joints. This is an important fact to remember, particularly when dealing with an acute purulent bursitis, as it is important not to involve the joint by a careless surgical attack, nor to allow the infection to persist until the joint has become involved by extension. Bursae normally contain only sufficient fluid to allow their surfaces to glide smoothly over each other, but when infected, or subjected to repeated trauma, the walls may be very much thickened and the sac distended with fluid. Bursae which originally have become distended by trauma, may become secondarily infected. This is often seen in bursae overlying a bunion. Owing to the poor blood supply to the bursal walls, these effusions are rarely hemorrhagic, unless the wall of the bursa is ruptured or torn.

In the chronic types, particularly of the infectious variety, certain changes take place both in the bursa and in the tendinous muscle insertions lying under it, the exact nature of which can not be explained. In many of the chronic bursae, the roentgenogram will show an opaque mass lying in or just beneath the bursa. At operation the walls of the bursa may be found somewhat thickened, the cavity partially or wholly obliterated by adhesions and rarely a calcareous deposit within the sac.

Bursitis of the Foot and Ankle

Under the stimulation of constant trauma or pressure, bursae may develop over any of the bony prominences of the foot and ankle. A bursa, known as tailors' bursa, may form over the external malleolus. In certain deformities of the foot, large bursae may occur over the area on which the weight is borne, *e. g.*, the bursa formed on the sole of the foot over the heads of the metatarsal bones when the heads of the bones are depressed. The retrocalcaneal bursa is commonly present between the tendo achillis and the tuberosity of the os calcis. Inflammation of this bursa may develop in connection with disturbances in the growth of the epiphysis in children, usually between the eight and fifteen year, or may be caused by pressure from ill-fitting shoes. When distended, it forms a painful fluctuating swelling over the back

of the heel. In the acute stage, hot applications should be employed. The counter should be removed from the shoe when walking is permitted. The inflammation is frequently persistent and continues for months after the pressure has been relieved. Suppuration with sinus formation is occasionally seen. Excision of the bursa may be bome necessary if it does not respond to conservative measures. Inflammation may also occur in the bursa lying between the insertion of the tendo achillis and the overlying skin, and is known as achillobursitis.

The symptoms and treatment are similar to those of retrocalcaneal bursitis. Calcaneobursitis is an inflammation of the bursa beneath the os calcis between the bone and the fatty tissue of the heel and may be associated with the formation of calcaneal spur. The symptoms are pain and tenderness on pressure, which is aggravated by standing and walking. The treatment consists of felt or rubber pads under the heel to remove the jar of walking, and in obstinate cases the bursa may be excised.

The most common bursa seen on the foot is the bunion, which develops over the exostosis of a hallux valgus, Ordinarily, treatment is not directed to the bursa, but to the bony deformity which has caused it. Occasionally, however, the bursa itself may become infected and require drainage or removal before an operation can be performed on the hallux valgus.

Bursitis of the Knee

Numerous bursae occur about the knee joint in connection with the attachments of the various muscles and ligaments to the tibia and femur. Their presence is not constant and they are of little practical importance. Some of them communicate with the knee joint and become distended in chronic effusion into this joint. The bursae about the knee joint which most frequently produce symptoms are the prepatellar bursa, the subaponeurotic bursa, the bursa situated in relation to the medial head of the gastrocnemius muscle, and the one beneath the tendon of the semimembranosus muscle.

Prepatellar Bursitis.—This bursa is present in about 90 per cent of normal individuals, and covers the lower half of the patella, but may extend over the upper half as a separate compartment, or as an extension of the primary sac. It is frequently involved in traumatic and infectious lesions, and is most common in women of the servant class, or those whose occupation requires working on the knees, and is commonly known as housemaid's knee. This is perhaps the most

usual location for the syphilitic type of bursitis. Differentiation from osteomyelitis and tuberculosis of the patella must be made and this is usually not difficult, but, occasionally, in the suppurative type when necrosis of the superficial portion of the patella occurs, it is difficult to determine which was the original condition. Inflammation of the prepatellar bursa rarely involves the knee joint, due to the dense ligamentous and fibrous structures which completely cover the posterior and the lateral aspects of the bursa and separate it from the joint.

Treatment.—The treatment in the acute stage consists of such measures as are applicable to acute infectious processes elsewhere in the body. The fluid may be aspirated and the aspiration repeated as often as necessary, but in the more advanced stages, the serous exudates rapidly reaccumulates and aspiration, therefore, does not give permanent relief. Hot moist applications are useful during the acute stage, and also strapping of the joint with adhesive tape may limit the swelling. If the exudate becomes purulent, drainage of the bursa is necessary, and is best performed through two lateral incisions, one on either side of the patella. Complete excision of the bursal sac is the most successful method of treatment. Excision may be performed, either through a longitudinal midline incision, or preferably through a transverse incision. The sac is separated from the skin above and from the patella below and completely removed. The knee should be immobilized, following the operation, for a week or ten days until the wound is healed. Active function may then be resumed.

Subaponeurotic Bursitis.—A deep subpatellar or infrapatellar bursa of small size lies between the upper part of the tuberosity of the tibia and the ligamentum patellae and is separated from the synovial membrane of the knee joint by a pad of adipose tissue. This bursa, when distended, causes a fluctuating swelling which obliterates the depression on each side of the ligamentum patellae, while the center is depressed because of the resistance of the ligament. The treatment is similar to that of prepatellar bursitis.

When the bursa beneath the medial head of the gastrocnemius muscle and the one beneath the tendon of the semimembranosus muscle are affected, there is a swelling on the posterior aspect of the knee joint. Flexion of the knee is limited, due to mechanical obstruction of the enlarged bursa, and the other symptoms, such as pain and inflammation, are present. Treatment consists usually of excision.

Bursitis of the Hip

Numerous bursae about the hip joint have been identified. According to Bryant and Burk, a total of thirty-one have been described by various authors. However, only three are of practical importance, the bursa over the greater trochanter, the iliopectineal bursa, and the ischiogluteal bursa.

Trochanteric Bursitis.—The bursa over the greater trochanter lies between the tendinous attachment of the gluteus maximus and the lateral surface of the greater trochanter. This bursa is constantly present and is of considerable size. Inflammatory changes occur which are accompanied by recognizable signs and symptoms, if the anatomy of this region is kept in mind. Disease of the bursa must be distinguished from an acute epiphysitis or osteomyelitis originating in the greater trochanter and disease of the hip joint. Pain and tenderness, usually not severe, are localized just behind the greater trochanter, and can be elicited by palpation over the area or by rotating the limb. When the bursa is distended the hollow behind the greater trochanter is obliterated and the limb is rotated outward to relax the gluteus maximus muscle. Passive motion in the hip joint is not painful and there is no flexion contracture.

Treatment.—If the inflammation is accompanied by signs of an acute purulent infection, the bursa should be aspirated to determine the presence of pus, and, if found, incision and drainage should be instituted. The incision is made just posterior to the greater trochanter, care being taken not to go too far posteriorly and injure the sciatic nerve which lies close to the trochanter when the hip is rotated externally. In the nonsuppurative lesions, rest and physiotherapy are usually sufficient.

Iliopectineal Bursitis.—The large iliopectineal bursa lies between the iliopsoas muscle and the pelvis; posteriorly and above, it is in relation with the iliopectineal eminence, and below to the capsule of the hip joint. It accompanies the femoral nerve and frequently communicates with the hip joint. When inflamed, tenderness and pain are present in the lateral portion of Scarpa's triangle. As the swelling becomes larger, fluctuation may be demonstrated and the anterior projection may be sufficient to obliterate the inguinal groove. Pressure on the femoral nerve causes referred pain down the leg and in the knees as in hip joint disease. If tenderness and pain are present, there will be flexion of the thigh with increase of the pain upon extension of the leg. These symptoms resemble those of psoas abscess and hip joint disease, and distinction between these conditions and bursitis

is often extremely difficult. Aspiration will frequently clear up the diagnosis.

Treatment.—The treatment is incision and drainage or complete excision. The bursa is best reached by a vertical incision external to the femoral artery, retracting the fibers of the iliopsoas muscle inwardly. The surgeon should remember that the bursa often communicates with the joint cavity and that drainage of the hip joint is often required.

Ischiogluteal Bursitis.—The ischiogluteal bursa lies over the tuberosity of the ischium. Inflammation of this bursa, occasionally seen in patients whose occupation necessitates constant sitting on a hard surface, such as boatmen, weavers, or coachmen. The bursa may become distended and cause pain over the tuber ischii, sometimes radiating down the leg, and may be confused with a sciatic neuritis. Change of occupation will usually effect a cure, but if the symptoms are severe and persistent, removal of the bursa is indicated.

Bursitis of the Shoulder

Disability in the shoulder joint characterized by pain and limitation of motion is of frequent occurrence. The picture is familiar to all, yet it is often very difficult to make an accurate differential diagnosis as to the exact location of the disease process, or as to the true etiologic factors involved in its production. This is due to the fact that the predominant symptoms, pain, and limitation of motion, are common to irritation or inflammation, both of the shoulder joint proper and of the other structures lying in proximity to it. The bursae about the shoulder joint which are commonly affected are the subacromial, the acromial, and the subscapular bursae.

Acute Subacromial Bursitis.—The subacromial bursa is the most important of these auxiliary structures because of its frequent involvement by traumatic and infectious processes. The onset of an acute subacromial bursitis usually begins with a feeling of discomfort and aching in the region of the shoulder, rather indefinite at first, but rapidly advancing until at the end of twelve to twenty-four hours there is a definite circumscribed area of tenderness just below the acromial process, with sharp, neuritis-like pains extending down the arm and up into the neck. Motion rapidly becomes limited by protective muscle spasm. Abduction and external rotation are particularly restricted, and if forced, exquisite pain is produced, usually referred to the insertion of the deltoid muscle. Careful manipulation of the arm will show that considerable backward and forward motion is permitted, but if

an attempt is made to abduct or rotate the arm, immediate pain is produced and the entire musculature of the shoulder spasmodically contracts. There is sometimes a history of direct trauma, but more often the patient states that the onset of pain followed the performance of some unusual exercise, such as painting a ceiling or carrying some object on the shoulder. A fulness may be detected under the deltoid muscle joint below the tip of the acromion process. On palpation this gives a sensation of fluctuation and the pressure reproduces the same pain caused by abducting the arm. The swelling is circumscribed and localized to the area occupied by the subacromial bursa. If the arm can be rotated the tense swollen area can be felt to move with the humeral head. The pain, of a dull boring character, is often of sufficient severity to keep the patient awake at night. Any unguarded motion of the shoulder is apt to produce a sharp acute twinge of pain in the bursa, radiating down the arm and up into the neck. The pain and disability in the acute cases usually subside in about two weeks and the condition clears up. In some cases, however, the pain never quite disappears and the shoulder remains irritable or weak. Exposure or any unusual exercise may bring on a partial return of the original symptoms, and the condition progresses into the chronic stage.

Treatment.—If conservative measures are used to prevent muscle contractures and restore complete function, no serious sequelae will result. The pain can be relieved in most cases by placing a soft pad in the axilla and fixing the arm to the side with supportive bandages. After a few days physiotherapy consisting of baking and massage, diathermy, and careful active and passive motion may be started. In those in whom the pain is not relieved by these measures, traction on the arm may be necessary. Traction at first will have to be parallel to the body with the arm at the side, but as the muscle spasm relaxes more abduction may be secured till the arm is finally at right angle to the body. Counterbalanced traction upward may now be added on the forearm, and the whole extremity suspended in a position of external rotation. This effectually prevents the development of contracture with the arm adducted and internally rotated. In every case where it is apparent that the acute symptoms may continue for more than ten days or two weeks, an ambulatory splint holding the arm in abduction and external rotation should be used. A careful search for all foci of infection should be made and any suspicious foci removed as soon as the acute symptoms have subsided. Future attacks may be prevented in this way. Heat, preferably in the form of hot moist packs, does much to relieve the pain. Sufficient sedatives are necessary to give

the patient rest. Sodium salicylate, aspirin, or atophan are often beneficial.

Chronic Subacromial Bursitis.—The chronic type of subacromial bursitis is a much more serious and disabling condition, since the disability is more the result of the secondary changes in the muscles about the shoulder joint than to the disease of the bursa itself. Chronic bursitis may succeed an attack of acute bursitis, but more often the onset of the disability is gradual and the patient does not seek treatment until the secondary muscular contractures have become well advanced, and the function of the shoulder seriously impaired. The usual history is that the patient has had rheumatism or neuritis in the shoulder for

Fig. 403.—Subacromial bursitis with calcified deposit in the bursa.

months. Periods of relief have been followed by exacerbations of pain, usually following exercise, and each attack has left the shoulder weaker and more irritable. An unusually severe attack of pain or a realization that the use of the shoulder is gradually being lost prompts the desire for an examination by a physician. During severe exacerbations the patient presents a typical picture. His face is worn from suffering and loss of sleep; the affected arm is supported across the chest by the opposite hand; the shoulder is elevated and the body is tilted away from the painful side. He is apprehensive, carefully guarding the arm, as any movements cause a severe twinge of pain. Greater comfort is secured by sitting with the arm supported than by lying down. The pain is described as a constant dull ache in the shoulder, replaced at

intervals by sharp knifelike paroxysms radiating over the back of the neck and down the arm on the affected side. The examination shows the arm fixed to the side by muscle spasm and contracture. The trapezius muscle is rigid, holding the shoulder higher than the normal side, and there is muscular atrophy over the entire shoulder. The skin may be somewhat glazed, but there is no localized redness or heat. Motion is limited in all directions, a moderate amount of backward and forward movement is permitted, but attempts to abduct or externally rotate produce severe pain. Often all the motion present is in the scapulothoracic joint and care must be taken by the examiner to fix the scapula or he will be deceived as regards to the actual motion in the shoulder joint proper. In the chronic type the picture is much the same, except for the absence of the acute pain, tenderness, and muscular spasm.

Treatment.—The treatment of chronic subacromial bursitis is a difficult problem. There is a serious loss of function in the shoulder which is fixed by firm muscular contractions and adhesions, complicated by an atrophy of disuse in the soft parts and bones. All motions are painful. The inflammatory condition of the bursa has now become only a minor part of the pathologic picture. Restoration of function in the shoulder is the object of treatment, to secure which there must be a careful consideration and weighing of each individual component of the disability. The first consideration is the relative importance of the bursa, as on this point rests the decision whether the case is to be treated surgically or conservatively. Many surgeons advise the removal of the calcareous deposits shown by roentgenogram to be in the region of the bursa, before conservative measures are begun. Many of the plaques are absorbed spontaneously, and in other cases the function of the shoulder is restored in spite of their presence. On the other hand, after conservative measures have been given a thorough trial without improvement, and the deposit as shown by the roentgenogram, is still present, the removal of the foreign body by operation is indicated. The object of the conservative treatment is to clear up the inflammatory process in and about the bursa and to restore function in the shoulder by gradually stretching the contracted muscles. This requires patience and cooperation on the part of the patient and careful supervision of the physiotherapy by the physician. Occasionally a contracture may be encountered which does not yield to the gradual method of stretching after weeks of such treatment. Providing that limitation of motion is not due to intra-articular adhesions, manipulation under anesthesia often aids in the restoration of motion. This manipulation should be carried out very gently and slowly. Physio-

therapy is extremely important following those manipulations or recurrence of adhesions will take place. Active exercises by the patient should be carried out systematically. They are an essential part of the treatment and it is upon them that the final restoration of function depends. The wearing of an abduction splint at night is often of advantage.

Surgical treatment consists of the removal of the bursa and any deposits that may be formed within the bursa or the tendon of the supraspinatus muscle. The bursa is exposed by an incision beginning at the tip of the acromion process and extending down about 3 inches parallel to the bicipital groove. The fibers of the deltoid are separated down to the bursa which lies in close proximity to the greater tuberosity of the humerus. The bursal sac is opened, its limits defined by rotating the humerus and the sac removed. The tendon of the supraspinatus muscle is examined and if infiltrated with a grayish white deposit, the entire diseased portion of the tendon is excised. The wound is closed without drainage.

Acromial Bursitis.—The acromial bursa lies over the outer end of the acromion process and serves to protect the bony prominence of this portion of the acromion from pressure and contusions. It does not communicate with the shoulder joint or any of the other bursae. Acromial bursitis is seldom caused by a single injury, but is usually the result of repeated trauma over the outer end of the acromion process caused by the constant carrying of weight on the shoulder. This form of bursitis was observed in water-carriers in ancient times and in hod-carriers of today. The bursa is rarely involved in chronic inflammatory changes of infectious origin, but may occasionally be involved by an acute purulent inflammation engrafted on a preexisting chronic traumatic bursitis. When distended, the bursa appears as a rounded, fluctuating swelling just above the tip of the shoulder and lying over the crest of the acromion process. It is usually about an inch in diameter, but may occasionally become enlarged to 2 or 3 inches, and is felt subcutaneously attached to the bone. The bursa is distended, but is not tender unless secondarily infected. If the distention is the result of a single trauma, conservative treatment, such as hot or cold applications, or aspiration, followed by adhesive strapping, will probably effect a cure. If the condition has been present for some time, or has occurred repeatedly, or if the bursa has become infected, surgical excision is the treatment of choice. Care should be taken to dissect out the entire sac, which may be done easily under local anesthesia.

Subscapular Bursitis.—This is a small bursa, lying on the anterior medial surface of the humeral head, between the tendon of the sub-

scapular muscle and the capsule of the shoulder joint, and constantly communicates directly with the shoulder joint. It is rarely involved, except in conjunction with disease of the joint proper, and is important only as a point of secondary pocketing in purulent affections of the joint.

Bursitis of the Elbow

Inflammatory affections of the bursae about the elbow are less common than affections of the bursae about the other large joints. Two bursae, however, are at times involved, viz: the olecranon bursa and the radiohumeral bursa.

Olecranon Bursitis.—The olecranon bursa, which is regularly present, lies over the olecranon process, and separates the tendon of the triceps muscle from the posterior ligament of the elbow and the olecranon process. Its purpose is to facilitate the movement of the triceps tendon over the bone at this point. Normally so small that its presence is not evident, under the irritation of repeated trauma, it may become greatly distended and appear as a rounded tumor. This form of bursitis, or miners' elbow, is caused usually by repeated trauma and is characterized by distention of the bursa and thickening of its walls. A rounded fluctuating tumor about $1\frac{1}{2}$ by 1 inch in size appears over the olecranon. The first appearance usually follows some unusual trauma, but the subsequent distentions may follow minor injuries or appear spontaneously, and later, after the wall has become thickened and degenerated, the fluid is no longer absorbed and the enlargement persists indefinitely. Unless the distended bursa is the result of severe trauma, or is secondarily infected, it is not tender and does not interfere with the motion of the elbow. The condition is unmistakable and the diagnosis self-evident, unless complicated by infection. When this occurs it is sometimes difficult to differentiate it from a cellulitis about the elbow or an infection in the elbow joint; usually there is a history of swelling over the olecranon previous to the infectious condition. The point of maximum tenderness and swelling lies over the olecranon and fluctuation at this point can be obtained. Motion in the elbow joint is seldom restricted.

Treatment.—The primary attack of a simple traumatic bursitis usually responds to aspiration followed by a compression bandage. If the swelling reappears, the sac should be dissected and removed completely. The injection of irritating substances, such as iodine or carbolic acid, in the hope of producing adhesions and obliteration of the sac, is unsatisfactory. The results of such measures are very uncertain and the reaction is often more disabling than surgical removal.

Radiohumeral bursitis (tennis elbow) is a rather unusual and obscure condition, the exact pathology of which is still somewhat in doubt. It is characterized by a feeling of discomfort, often of acute pain localized over the outer surface of the elbow, with a point of definite tenderness over the external epicondyle of the humerus or the radiohumeral joint. Osgood explains the condition as an inflammation of a small bursa lying between the conjoined tendon and the radiohumeral joint. Other theories, such as tearing off the muscle fibers from the external epicondyle, a periostitis at this point, or a pinching or injury to the radiohumeral capsule, have been offered as explanations.

Symptoms.—Following a game of tennis, or some continuous labor, discomfort, amounting sometimes to acute pain, is felt in the region of the elbow. The tenderness may seem to be directly over the epicondyle of the humerus, but with careful observation, its exact location will be found to vary with different positions of the elbow. The condition at first is not constantly annoying, but after weeks or months of interference with his sport or occupation, the patient seeks medical aid. Another typical symptom is the sudden sensation of weakness when an attempt is made to lift an object, like a glass of water, a plate, or a book, with the elbow fully or partially extended and the forearm muscles, especially the extensors, set. Inspection at first shows nothing abnormal, but, if the sound and the affected limbs are placed in identical positions, for example, the hands resting on the pubes, there will be noticed a slight fulness over the distal tip of the epicondyle of the affected elbow, extending distally and mesially, and filling up the slight normal depression over the radiohumeral joint. Palpation also first seems to yield negative results. There is no elevation of local heat and no sharply marked swelling, but over the area of tenderness, by careful examination, a feeling of increased elasticity may be appreciated. The tenderness at first seems to be sharply localized over the epicondyle, but, in reality, it is usually slightly distal and mesial over this portion of the radiohumeral joint, and shifting slightly in different positions of flexion and extension, supination and pronation. In certain positions, usually extreme pronation, there may be no tenderness whatever over the epicondyle. The motions are free, and when passively carried out, are painless. The roentgenogram commonly shows no pathology, though evidence of periostitis has been reported by some observers.

Treatment.—In the acute stage, conservative methods should be given a thorough trial before excision of the bursa is considered. The elbow should be immobilized to prevent further irritation. Physiotherapy consisting of baking and light massage or diathermy has been

found of material aid. This treatment should be continued for two to four weeks, after which use of the arm may be resumed, but the patient cautioned against strenuous exercise or a repetition of the movement which originally caused the disability. Recurrences, even after months of quiescence, are common. After recurrence or when the condition has reached the chronic stage, conservative measures are unsatisfactory. Pain of varying degrees of severity results from excessive work, often making it necessary for the patient to give up his occupation unless relieved. Operative removal of the bursa is advisable in severe cases. An oblique incision is made over the radiohumeral joint, extending from above the external epicondyle well down over the head of the radius. The conjoined tendon of the extensor muscles is split and if a definite bursal sac is found, it is removed. If no definite bursa is found, the tissue between the conjoined tendon above and the epicondyle and radiohumeral capsule below is dissected out. In cases where doubt exists as to the presence of a bursa, the radiohumeral joint should be explored and the outer portion of the epicondyle removed.

AFFECTIONS OF THE VASCULAR SYSTEM

Affections of the arteries and veins of the extremities may produce symptoms which simulate lesions of the bones and joints. The orthopedic surgeon is, therefore, frequently required to make a differential diagnosis before rational treatment can be instituted. The classification of Brown and Henderson assists materially in differentiating the main types, which are functional or vasomotor disturbances, of both local and general distribution, and organic types which may also be local or general.

Raynaud's disease is caused by a primary vasoconstriction of the arteries. It occurs most frequently in young adults and is characterized by intermittent attacks of pallor, lowered surface temperature, cyanosis, and at times congestion and livid swelling of the extremities. The attacks are accompanied by intense pain and the condition may eventually result in trophic disturbances or gangrene.

Erythromelalgia.—The disease known as erythromelalgia was described by Weir Mitchell. The feet are more often affected than the hands. The cause of the condition is paroxysmal dilatation of the arteries, capillaries, and veins, which may be brought on by exercise, hot weather, and occasionally by excessive bed clothes. The attacks are marked by burning pain, redness of the skin, throbbing of the arteries, swelling and elevation of local temperature. The pain is increased by walking and by the dependent position of the limb. No

organic basis is known, but the functional nature of the disease is obvious from its intermittent character, nonprogressive course, and the relief afforded by cold and change of position. Gangrene and trophic changes do not occur since the blood supply is not decreased.

Thrombo-angiitis obliterans (Buerger's disease) is due to a chronic inflammation of the intima of the blood vessels with clot formation. There is no known specific cause for the disease, but the excessive use of tobacco, especially cigarettes, has been mentioned as a predominant etiologic factor and the incidence is greater in the Jewish race. The disease affects the male sex only. Intermittent claudication, or lameness after exercise, is one of the earliest and most important symptoms. Coldness and color changes in the extremities are subsequent phenomena. The color change is most striking, marked rubor or reddish cyanosis appearing in the feet when they are dependent and pallor when they are elevated. Trophic disturbances with ulcerations and gangrene occur constantly in the late stages of the disease, and the pain at that time is usually excessive and continuous without relation to exercise.

Arteriosclerosis may be local or generalized and may or may not be associated with thrombosis. The senile type of gangrene and diabetic gangrene are the two most common members of this group. The symptoms are similar to those in Buerger's disease, but the pain is usually of less severity.

Diagnosis.—The differential diagnosis of the various types and subtypes of arterial disease causing pain in the lower extremities is quite difficult, as is also the separation of those conditions from the static, traumatic, and infectious groups of affections. A careful history noting the sequence, frequency, and duration of the symptoms, palpation of the peripheral arteries, and other tests to determine the efficiency of the circulatory system will usually be sufficient. The efficiency of the circulation may be determined by comparing the color of the extremity after elevation and following dependency; when the arteries are obstructed a varying degree of pallor appears within a few minutes when the limb is elevated. When the feet are held in the dependent position, the color is restored gradually, becomes a livid red hue or cyanotic; the color appears first in the toes and gradually spreads upward to the foot, ankle, and leg, the extent of the reaction depending largely upon the degree to which collateral circulation has been established.

The accurate determination of the rate of heat loss, surface temperature, and salt absorption from the injection of saline solution in the form of an intracutaneous wheal, as suggested by Stern, are also of scientific interest and value in the diagnosis. In the absence of edema,

the intracutaneous salt solution test is a simple, rapid, and accurate method of determining circulatory deficiencies in the extremities. Sixty minutes or more is the normal disappearance time of the salt solution. In all instances in which clinical circulatory deficiency exists, the disappearance time is diminished; in the area just above the seat of a gangrene (existing or threatened), it is frequently as low as five minutes. The roentgenogram is usually of little aid, except when calcification of the vessels has occurred in arteriosclerosis. The injection of opaque substances into the vessels is associated with too great risk to be universally applicable.

Treatment.—Prophylactic treatment consists of measures for the protection of the extremities against trauma and exposure to sudden changes in temperature. The use of tobacco should be prohibited in thrombo-angiitis obliterans and strict dietary instructions given to those suffering with arteriosclerosis. Ringer's solution in large quantities, intravenously or orally, has been advised in Buerger's disease and salicylates and opiates are frequently required for the relief of pain. In diabetic gangrene, the diet should be regulated and insulin administered. The surgical treatment in the past has consisted entirely of amputation. The selection of the site of amputation is an important problem. In many cases, however, it is well to amputate high above the pathologic process, going above the knee in order to prevent sloughing of the stump and reamputation. Recently, periarterial sympathectomy and lumbar sympathetic ganglionectomy have been reported as successful in Raynaud's disease.

BIBLIOGRAPHY

Brown, George E., and Henderson, Melvin S.: The Diagnosis and Treatment of Arterial Vascular Disease of the Extremities, Jour. Bone and Joint Surg., 9: 613, 1927.

Buerger, Leo: Thrombo-angiitis Obliterans, Amer. Jour. Med. Sci., 136: 567, 1908.

Davidson, Edward C.: Tannic Acid in the Treatment of Burns, Surg., Gynec. and Obst., 41: 202, 1925.

Dupuytren, Guillaume: De la retraction des doigts par suite d'une affection de l'aponevrose palmarie; operation chirurgicale qui convient dans ce cas, J. univ. et hebd. de med. et chir. prat., 5: 348 (Ser. 2), 1832.

Kanavel, Allen B., Koch, Sumner I., Mason, Michael L.: Dupuytren's Contraction, Surg., Gynec. and Obst., 48: 145, 1929.

Kroh, F. R.: Snapping or Trigger Finger, Arch. of klin. chir., 136: 240, 1925.

Mitchell, Weir: Case of Erythromelalgia, Jour. Ner. and Ment. Dis. (N. S.), 9: 638, 1884.

Osgood, R. B.: Radiohumeral Bursitis, Epicondylitis Epicondylalgia (Tennis Elbow), Arch. Surg., 4: 420, 1922.

Stern, Walter G.: Saline Wheal Test as Measure of Blood Supply in Arterial Disturbances of Extremities, Amer. Jour. Ophthalmol., 11: 1, 1928.

Verneuil, A.: Hygroma de le main dans la syphilis secondaire, Gaz. hebd. de méd., 5: 609, 1868.

CHAPTER XV

AFFECTIONS OF THE NERVOUS SYSTEM

ANTERIOR POLIOMYELITIS

Anterior poliomyelitis, or infantile paralysis, is an acute infectious communicable disease, involving the cerebrospinal system, and is usually associated with peripheral paralysis. The paralysis is flaccid in type and the muscles whose enervation is derived from the lumbar enlargement of the spinal cord are chiefly affected.

Historical Review.—Unlike most diseases of epidemic character, which may be traced historically in literature to very early times, poliomyelitis is practically unmentioned until the year 1840. The first description in medical annals was published by Underwood in 1793, who, however, did not appreciate the true cause of the illness, believing that it arose from debility, although he noted that the paralysis usually affected the lower extremities. Shaw connected the disease with weaning. The first systematic study of the disease was made by Von Heine who outlined clearly the important features of the disease, and was the only one of the early observers to recognize that the pathologic process attacked the spinal cord, although he had no microscopical proof to substantiate his hypothesis. Somewhat later, his theory was proved to be correct, and in the second edition of his monograph, published in 1860, he termed the disease "infantile spinal paralysis." Von Heine also noted the acute febrile period preceding the paralysis, and suspected the contagiousness of the disease. Cornil, in 1863, was the first to describe the pathologic changes in the spinal cord, but while he noted the atrophied condition, he failed to recognize the important feature, the destruction of the anterior horns. A few years later, Prevost and Vulpian called attention to the affection of the anterior cornua. The true significance of these changes of the spinal cord was first appreciated by Charcot, who associated the atrophy of the ganglion cells in the anterior horns with the muscle atrophy. An understanding of the true character of the disease, as it is known today, began with Medin's study, made during the first large epidemic which occurred in 1887, at Stockholm, Sweden. Wickman's contributions on this phase of the disease are also important. The occurrence of poliomyelitis in epidemic

form has been noted within recent years. It is probable that outbreaks did occur in earlier times, but undoubtedly they were overlooked, were not reported, or were confused with epidemics of other diseases that have features in common with poliomyelitis. The first appearance of the disease in epidemic form seems to have been in 1858 in the Scandinavian Peninsula. Gradually the outbreaks assumed significant proportions, until in 1905 the disease occurred in pandemic form in Europe. In 1907, poliomyelitis appeared for the first time over an extensive area of the United States, with the principal focus located in the Commonwealth of Massachusetts. There was a gradual spread of the disease westward with epidemic foci localized in the Middle Western states, especially Minnesota, and also in the southern and eastern parts of the United States.

Etiology.—The staphylococcus, streptococcus, pneumococcus, and numerous other bacteria have been suggested as the etiologic agent. Further bacteriological research was discouraged by the discovery that the virus was filtrable. Flexner and Noguchi announced that they had succeeded in isolating an organism from the central nervous tissue of cases of poliomyelitis, to which they gave the name "globoid bodies." More recently, Rosenow and his co-workers have made studies of the cultivation of a streptococcus which they obtained from the central nervous system and from the tonsils of humans and monkeys. The virus belongs to the filtrable class, as it will pass through the pores of a Berkefeld filter and asbestos. It withstands exposure to light, drying, freezing, heat, and glycerinization for a long time. Even at the height of summer heat and when dried on clothing, it retains its virulence. Ordinary weak chemicals, such as those contained in the solutions commonly used in the nose and throat, have no effect upon the virus and, therefore, do not aid in preventing the development of the disease. Since the infection in the epidemic type can be induced in monkeys by the injection of a solution of the infectious material from the central nervous system or elsewhere, which has been passed through filters sufficiently fine to retain all known bacteria visible through the microscope, it is believed that the causative agent is ultramicroscopic or is possibly a toxin so poisonous as to produce symptoms.

The nasal cavity is probably the site of entrance of the disease, as the monkey may be infected by the injection of the virus into the nasal cavities. It has not been definitely determined by what route the virus enters the nervous system from the nasopharyngeal mucosa. It may penetrate the blood vessels and be carried into the nervous tissues by the circulation, or it may penetrate the nervous tissue by way of the

sheaths of the olfactory nerve filaments. Experimental demonstrations have supported the latter route. When the virus has passed into the lymphatic vessels surrounding the olfactory nerves, it penetrates the subarachnoid space and is disseminated by means of the cerebrospinal fluid, following the invaginations of the arachnoid along the spaces of the anterior spinal vessels into the interior of the cord. Advancing columns of cells may be traced to their terminations about the anterior horn cells. The nasopharynx has also been suggested as the portal of exit of the virus. The virus has been demonstrated in the brain, cord, medulla, basal ganglia, cervical and lumbar enlargements, posterior root ganglia and their cranial analogies, and in the sympathetic ganglia. It has been found outside the nervous system in the nasal and pharyngeal mucosae, the tonsils, the mesenteric glands, and other lymph glands. The presence of the virus is difficult to demonstrate in the cerebrospinal fluid and blood, and injections of both fluid and blood have repeatedly failed to produce the disease in monkeys. In human beings, one attack of poliomyelitis ordinarily insures complete immunity; it is only in exceptional cases that reinfection occurs. At the present time, the monkey is the only animal that can be inoculated satisfactorily. Other animals, such as rabbits and guinea-pigs, which have shown a susceptibilty to the disease, have not developed lesions characteristic of poliomyelitis. As anterior poliomyelitis may occur as a sequela of acute infections, as measles, whooping cough, and during the clinical course of acute intestinal infections, and also sporadically and in epidemics, it is probable that several organisms may induce the same pathologic phenomenon.

Pathology.—The infection apparently has a selective action for the motor cells of the anterior horn of the gray matter in the cervical and lumbar enlargements of the spinal cord; other portions of the central nervous system may be involved, though the posterior portion of the cord is seldom invaded. The dissemination of lesions throughout structures and organs other than the nervous system has been determined. Lesions have been noted particularly in the lymphatic system and in the parenchymatous organs. The modern conception of the pathology of poliomyelitis recognizes two processes: (1) the hemorrhagic reaction with edema; (2) the destruction of the anterior cells. The paralysis depends upon the damage to the cells. It has not been determined whether the injury is due to the direct action of the virus or to toxic formations produced by it, or whether the damage is secondary to a hemorrhagic process in the interstitial tissue. The microscopical examination suggests that changes in the nervous system are the result

of a secondary lesion, and depend upon disturbances in the nutrition of the nerve, the accumulation of waste products, and the pressure of edema and hemorrhage. The earliest change consists of an acute meningitis, resulting from the infiltration of small mononuclear cells, probably lymphocytes, in the vicinity of the blood vessels of the leptomeninges. The vessels of the meninges are the source of blood supply to the cord, and as the pathologic process advances, the perivascular infiltration follows the vessels and enters the cord. This exudate may form a sheath which completely surrounds the vessels; in some cases it may be so great that it presses on the lumen and obstructs circulation. Hemorrhages varying in severity are frequently observed, the regions having the more abundant blood supply show correspondingly

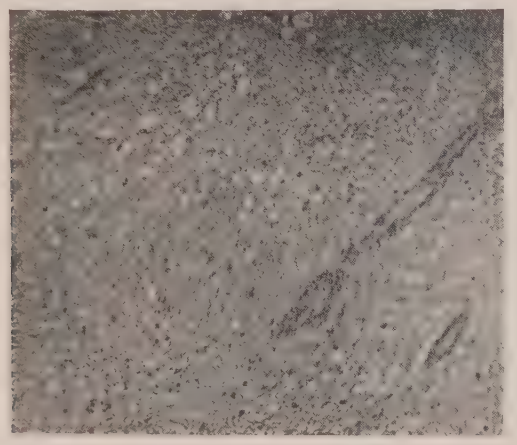


Fig. 404.—Section from spinal cord of fatal case of poliomyelitis showing perivascular infiltration of leukocytes.

greater vascular changes. The gray matter of the anterior horns, to which the blood supply is copious, shows marked lesions. The posterior gray matter is less often affected, although in some cases it may be densely infiltrated, especially in the region of Clarke's column. The white matter is very seldom affected. The tendency of the lesions to be symmetrical is probably due to the regularity with which the vessels supplying the cord are given off at different levels. Vascular and nerve cell changes similar to those in the spinal cord are found in the brain stem, cerebrum, and cerebellum, but the lesions are less extensive. Changes similar to those in the spinal cord also take place in the posterior root ganglia. As a result of the destruction of the nerve cells in the anterior horn, the peripheral nerve atrophies, and the muscles supplied by that nerve degenerate.

The muscles whose nerve cells have been destroyed undergo metamorphosis until all muscular fibers may be substituted by fat. Some or all of the nerve cells may be destroyed or only temporarily impaired; in those destroyed restoration of the muscle to normal will not occur; in those partially or slightly impaired a return to normal or approach to normal may be expected. The degree of degeneration depends upon the amount of interference with the nerve supply. The atrophied fibers are easily recognized by their yellowish-white color. The tendons also atrophy from disuse and become weakened at the point where they are intersected by the degenerated muscle. The bones are often involved in the atrophic process, and the long bones of a paralytic limb are more slender than normal bones. The outer layer of the cortex is rarefied, and the medulla is reduced in quantity. Shortening may occur from lack of use and involvement of the nutritive centers. The capsule and ligaments become stretched and the joints become hypermobile and may be dislocated.

Symptoms and Clinical Course.—Formerly, the incubation period was considered to be under eight days, but recent investigations by Aycock and Eaton tend to show that the period averages fourteen days, and that the disease is probably most infectious within the first three or four days of the acute stage. In some cases the onset of poliomyelitis may be so slight as to be overlooked, and the paralysis is the first manifestation recognized. There are a number of clinical varieties which may be enumerated, as follows: (1) abortive; (2) cerebral; (3) medullary; (4) meningitic; and (5) spinal, the common type.

The abortive type is recognized only during epidemics. Fever is present for a number of days, but the condition subsides without paralysis. In the cerebral type the symptoms resemble those of an acute encephalitis or acute meningitis. The most prominent symptoms at the onset are convulsions, vomiting, and fever; otherwise, the onset simulates that of the ordinary spinal type very closely. In this type the chief lesion is located in the cerebrum, giving rise to paralysis of the spastic type. Ataxia without paralysis has been reported in some cases. In a small proportion of cases, the inflammatory process extends to the medulla and results in the involvement of the cranial nerve nuclei. In the medullary form the cardiac or respiratory centers may be involved with death occurring before diagnosis is made. The symptoms depend upon the nuclei involved. The facial nerve is most often affected. This variety is also recognized only during an epidemic. The meningitic type presents symptoms identical with cerebrospinal meningitis which can only be differentiated by the examination of the

spinal fluid. The cases in which the meningeal irritation is prolonged resemble tuberculous meningitis. Headache, vomiting, rigidity of the neck and back, opisthotonos, delirium, coma, Kernig's sign, strabismus, tonic and clonic spasms, and fibrillary twitchings of the muscles are among the most common symptoms. There may also be vasomotor disturbances in the form of flushing and paling of the skin. The cerebral, medullary, or meningitic types may be complicated by a peripheral paralysis.

The spinal, or common type, occurs with preponderant frequency and clinically there are four different stages: (1) acute or febrile; (2) initial paralysis; (3) resolution or functional improvement; and (4) residual paralysis. In the first, or febrile stage, the onset is sudden. The early symptoms consist of fever, drowsiness, sweating, headache, gastro-enteric disturbance, pain, hyperesthesia, and occasionally sore throat and difficulty with micturition or defecation. The fever varies from 100 to 105 F., but temperatures of 107 F. have been observed. It is generally conceded that fever is always present even if not detected. The high temperature is usually of short duration, lasting from one to six days. It may, however, continue abnormally elevated after the occurrence of paralysis. The pulse varies with the temperature in the febrile period. The respiratory rate rises and falls with the fever, except when the chest muscles are involved. Pain varies in degree; some patients suffer little while others suffer intensely. Pain on motion or on being handled is often so intense that the child lies very quietly and resents any disturbance. The pain may be localized in the extremities, in the back, along the nerve tracts, or it may extend over the entire body. Pain in the back of the head and neck, particularly on bending the head forward, is very frequent and is a suggestive symptom. The pain in the neck is usually accompanied by rigidity of the posterior muscles, which is easily recognized on an attempt to flex the head anteriorly. Pain is elicited in some cases by gently squeezing the muscles. Hyperesthesia, due to the early involvement of the posterior root ganglia, is a prominent symptom of the preparalytic stage. The

Fig. 405.—Involvement of facial muscles in anterior poliomyelitis.

slightest touch or even the pressure of the bedclothes will often cause pain. While the fever persists the child may be exceedingly nervous, drowsy, or there may be no symptoms suggestive of involvement of the central nervous system. When aroused, the patient is irritable and restless, plainly showing a desire to be unmolested. Nausea and anorexia are very frequent. Diarrhea has been a constant symptom in some epidemics. Retention of the urine occurs in a small proportion of cases. Muscular twitchings and a distinct tremor of the fingers are commonly present; convulsions are not common. Alterations in the reflexes depend upon whether the upper or lower neuron is involved. In the ordinary spinal case the reflexes are exaggerated during the febrile stage.

The nervous symptoms begin with the onset of paralysis and continue for about six weeks. As the acute febrile symptoms subside, flaccid or loose paralysis in the extremities is apparent. Paralysis usually appears during the first four days of the disease and in the majority of cases it comes on during the second day. There are some cases in which the paralysis appears without any preceding symptoms. Children may stumble and fall when paralysis begins to take place. In mild infections, the paralysis may be slight and may be unnoticed until walking is attempted, or months or years later, when deformity may ensue from deficient muscle balance. There seems to be a selective action of the organism on those cells in the spinal cord which affect certain groups of muscles. The paralysis may be of any group, or part of group, or may involve the entire muscular system. The distribution of the paralysis in frequence of occurrence is: both lower extremities, one lower extremity, all four extremities. At times, the cranial nerves may be involved as the speech center.

The stage of resolution or improvement is instituted as the nervous stage subsides, and there is a gradual return of muscular function. Muscle power is regained more rapidly during the first six months, and thereafter very slowly, becoming stationary in about eighteen months. The stage of residual paralysis is then instituted, and no further improvement is to be expected. This stage is in reality a status, the result of a pathologic condition, and does not represent an active pathologic process. There is partial or complete paralysis of certain muscles with atrophy of all the component parts of the extremity, including the bones. Deformity, which may be extensive, resulting from a lack of muscle balance, followed by contraction of the soft parts and structural distortions of bone, frequently complicates this stage. The deformities and dislocations are induced by the force of

gravity and by natural attitudes, as sitting with the hips flexed and abducted, the knee flexed, and the feet in equinus. The more common deformities will be described, beginning with the foot.

Fig. 406.—Equinus deformity of foot.

Fig. 407.—Same as Fig. 406. After operation.

The *foot* is the most dependent part of the body, and is obviously more subjected to strain and deformity, especially if weakened by

Fig. 408.—Paralytic talipes varus.

Fig 409.—Same as Fig. 408. After operation.

paralysis. The deformities most frequently observed are equinus, varus, valgus, calcaneus, cavus, equinovarus, calcaneovalgus, and equinovalgus, drop foot and flail foot. *Equinus* is caused by the paral-

ysis of the anterior group of muscles in the leg, or the dorsal flexors, with active function in the posterior muscles of the leg, especially the gastrocnemius. The posterior muscles contract as muscle balance is lost, so that the patient walks on the ball of the foot. *Varus,* or turning in of the forefoot, ensues when the peroneal muscles are paralyzed and the tibial muscles are active. Coincidentally, there develops an inward twist of the tarsal bones and contraction of the soft structures on the inner aspect of the foot. *Valgus,* or turning out of the forefoot, is produced when the tibials are paralyzed and the peroneals are active. This obviously depresses the arch, and the condition may also be described as paralytic flatfoot. *Calcaneus,* or heel-walking, occurs when the posterior or calf muscles are paralyzed and the anterior group of the leg is active. In all these deformities, there is usually structural distortion of the bones. There are also certain combinations of deformities, as equinovarus, calcaneovalgus, and equinovalgus, which result from contracture of the active muscles, and are fixed by the permanent contraction of muscles and soft tissues and the distortion of the bones. *Equinovarus* is produced when there is paralysis of the extensor and peroneal muscles, while the posterior group and tibials are active. *Calcaneovalgus* is induced by paralysis of the posterior group and tibials with active peroneals and anterior muscles of the leg. The latter become contracted from loss of muscle balance and pull the foot upward and outward. *Equinovalgus* may be caused by paralysis of the anterior group and tibials with active posterior muscles and peroneals, or may follow simple equinus without paralysis of the tibials by the foot being forced outward by weight-bearing in a compensatory effort to place the sole of the foot on a flat surface in walking. Drop foot occurs when the anterior muscles are paralyzed and the posterior muscles are active, but without contraction, even though a loss of muscle balance is present. When the leg is lifted from the ground in walking the foot falls downward. Flail foot or dangle foot results from paralysis of all muscles of the leg. A flail foot is also a drop foot, but a drop foot is not necessarily a flail foot. A description

Fig. 410.—Paralytic talipes valgus

of deformities of the foot may also be found in the chapter on Congenital Anomalies.

The Knee.—Fixed flexion deformity of the knee results from paralysis of the quadriceps muscle. In addition there may be associated

Fig. 411.—Same as Fig. 410. After operation.

external rotation and subluxation of the tibia on the femur by a strong pull of the biceps femoris muscle on the head of the fibula and the outer tuberosity of the tibia. Genu recurvatum, or exaggerated hyperextension occurs when the hamstring muscles are paralyzed and the

Fig. 412.—Talipes calcaneovalgus.

Fig. 413.—Same as Fig. 412, after reconstruction.

quadriceps is active. Genu recurvatum may also be a natural compensatory measure to fix the knee and enable standing and walking when all muscles of the thigh are paralyzed and a flail foot exists.

The hip is more frequently fixed in flexion with abduction by con-

traction of the flexor and abductor muscles; the contracture may be so extreme and the anterior aspect of the thigh touches the abdominal

Fig. 414.—Flexion deformity of knee.

Fig. 415.—Same as Fig. 414, showing correction of flexion deformity of knee.

Fig. 416.—Genu recurvatum.

Fig. 417.—Same as Fig. 416, showing correction of genu recurvatum after operation of transplantation of patella to tibia.

wall when the spine is in the normal position. Dislocation of the hip from paralysis of the gluteal muscle is common.

The Spine.—The loss of muscular balance may cause slight or extreme curvature of the spine. Visceroptosis may result from paralysis of the abdominal muscles.

The Shoulder.—In involvement of the upper extremity the deltoid muscle of the shoulder is most frequently paralyzed. This causes loss of abduction and there may be dislocation by gravity, which is often erroneously considered of traumatic origin. In traumatic dislocation, however, the shoulder can not be reduced without considerable force, whereas, in paralytic dislocation, the head of the bone can be slipped in and out of place without discomfort.

The Elbow.—The function of the elbow may be impaired by paralysis of either the flexor or extensor group of muscles; the joint is loose and flail, the problem being one of function and not deformity.

The wrist may become flexed and subluxated, and a peculiar type of claw-hand develop. The fingers are usually extended at the metacarpophalangeal joints and flexed at the interphalangeal joints; paralysis of the intrinsic muscles of the thumb causes serious disability from loss of power to oppose the thumb to the other fingers.

Fig. 418.—Method of progression in paralysis of quadriceps muscle by supporting the thigh with the hand.

Diagnosis.—The early diagnosis of poliomyelitis is sometimes difficult, but its recognition in the preparalytic stage is of great importance if the spread of the infection is to be suppressed, and the progression of the paralysis prevented. The characteristic symptoms of the disease are a febrile reaction, pain and stiffness in the neck, hyperesthesia, and nervous irritability. A careful study should be made of the meningeal symptoms, as demonstrated by the condition of the reflexes, Kernig's sign, Brudzinski's head and leg signs, the intracranial pressure, and the anterior spinal-flexion sign. False interpretations may easily occur in the examination of children because of failure to secure relaxation. The anterior-flexion sign which consists of the development of a spastic state in the posterior neck muscles when attempts are made to flex the head, is one of the most important diagnostic

features, and is among the last of the symptoms of the acute stage to disappear.

Fig. 419.—Flexion contracture of hip.

The blood picture in poliomyelitis is not characteristic, and attempts to isolate a specific antigen for compliment fixation have so far been unsuccessful. There may be a leukocytosis of 15,000 to 30,000, with a relative increase of the polymorphonuclear cells. A spinal puncture is indicated when the clinical symptoms are suggestive. The cerebrospinal fluid is usually clear and flows under increased pressure. In a small number of cases it is cloudy or hazy, and the presence of a yellowish tinge signifies the presence of blood. As a rule, there is a

Fig. 420.—Paralytic scoliosis.

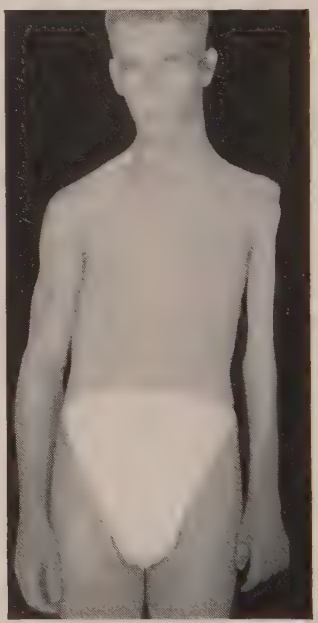


Fig. 421.—Paralysis and atrophy of muscles of left shoulder and arm.

definite increase in the number of cells. The normal fluid contains from 5 to 10 cells per cubic millimeter; the fluid in poliomyelitis may contain from 16 to 20 to hundreds or even thousands of cells per cubic millimeter. The cell count is usually highest during the first week, after which it decreases, until at the end of the second week the examination is practically normal. Both the globulin and albumin are usually slightly to moderately increased. The colloidal gold test has been found valuable by many investigators in the recognition of poliomyelitis. A prompt reduction of Fehling's solution is obtained in the majority of cases, but so far nothing of diagnostic value has been obtained by chemical studies of the variations in the protein, nitrogen, urea, ammonia, creatin nitrogen, creatinin, and sugar content.

Fig. 422.—Flexion contracture of hips and knees with quadruped locomotion.

In most cases after the paralysis is apparent, diagnosis presents little difficulty; however, there are cases, particularly among young children, which may require careful examination to determine the exact nature of the paralytic condition, as pain and not paralysis may be responsible for the failure to move the limb. In some cases is may be necessary to prick the different areas with a pin to determine whether or not the child has muscle control of the extremity; the paralysis may be determined by holding the child in different positions and noting the control of the extremities. The reflexes may be diminished or entirely lacking and in the late paralytic stage, atrophy and retarded growth, due to the impairment of the circulation, are significant signs. Electricity is of importance in examining the paralyzed muscles. The reaction of degeneration, which may be obtained by means of both faradic and galvanic currents, is of both diagnostic and prognostic value.

Poliomyelitis must be differentiated from the acute stage of other infectious diseases without paralysis, from other diseases of the nervous system, hysterical paralysis, painful osseous lesions as osteomyelitis, or fracture in infancy or early childhood, and from conditions presenting loss of power, due to other lesions than poliomyelitis, such as inflammatory conditions and injuries to the peripheral nerves. Differentiation can be made from the history of the onset and a careful comparison of the clinical symptoms with those of the confusing diseases. A thorough study of the conditions under which the disease occurred, an examination of the weakened limb, with observation of the condition of the refluxes, and an examination of the spinal fluid, are all necessary aides in making a correct diagnosis.

Fig. 423.—Same as Fig. 422, after operative correction.

Prognosis.—During the acute stage the prognosis as to life depends upon the location and extent of the pathology and the occurrence of complications, particularly that of pneumonia. The age of the patient and the severity of the symptoms also influence the outlook. In most cases, death follows simultaneous involvement of the respiratory centers, and the patient usually dies within seventy-two hours after the onset of paralysis. The prognosis as to life seems more favorable in young children than in infants under one year of age, or in older children or adults. After paralysis has existed for eight days, death is unlikely and is usually due to complications. Unfortunately, in the early stage there are no means by which the physician may judge the ultimate outcome as to function. After paralysis has occurred, the return of function depends upon the extent of destruction in the spinal cord. Muscles, whose cell control in the spine has been destroyed, can not be restored to action, but in those muscles whose controlling cells are only impaired, there may be a restoration to normal. In the stage of residual paralysis, much may be accomplished by the institution of efficient measures. If the disability involves only one foot, very often approximately normal function may be restored. If one limb alone is affected, walking may be made possible without crutches or braces.

If the lower extremities are severely contracted straightening the limbs may permit walking with crutches and apparatus. If the paralysis is extensive and the patient is confined to a rolling-chair or walks on his hands and knees, he can be placed on crutches with apparatus. A case is rarely observed which can not be materially improved. In the upper extremity much can often be accomplished to increase function by operations for stabilization and tendon transference.

Treatment.—There are four forms of treatment of poliomyelitis, the symptomatic, the preventive, the mechanotherapeutic, and the operative. Symptomatic treatment is indicated throughout all stages of the disease, but is applicable particularly to the acute febrile period. Preventive treatment is used during the acute stage in the hope of checking the onset of paralysis, and during the early paralytic stage in the hope that the paralysis will disappear, or cease to progress. Mechanotherapeutic treatment is carried out mainly during the early paralytic period, at which time the muscles are recovering. The operative treatment is used chiefly in the late paralytic period, when deformities have become more or less fixed, and when muscle imbalance and joint instability persist. During the acute stage, and as long as nervous symptoms persist, the child should be kept perfectly quiet, and the diet regulated carefully as in any acute febrile disturbance. Light foods and forced liquids are advisable. A cathartic, such as calomel, may be given to free the intestinal tract of any possible infectious agent. No treatment of the paralyzed muscles is necessary except supportive apparatus to prevent deformity. When pain from peripheral neuritis is severe, immersion of the child in a tub of tepid water may give relief.

Serum therapy has been introduced in an effort to arrest the progress of the infection, but its value is as yet undetermined. Various investigators, basing their opinions upon the discovery that one attack of the disease in monkeys confers immunity to reinoculation, have suggested some form of serum as a preventive measure. The administration of such serum is indicated as a possible beneficial agent and should be given when the diagnosis is made during the febrile stage or shortly thereafter. If any remedy is to arrest the process, it must be given at this stage; after paralysis occurs, no serum treatment is of the slightest benefit. The first application of serum in the treatment of human cases was made by Netter. When possible, the serum is obtained from persons who have had the disease within five years. It is generally agreed that the serum from cases of poliomyelitis of recent date, that is, from a two to six months' convalescent, is most

potent. As a rule, the neutralizing power is found to weaken with the elapse of time since the attack, although serum from cases of even thirty years' standing has been found to contain immune bodies. The blood of the donor and that of the patient must be compatible. A Wassermann test should also be made of the individual from whom the serum is obtained. One or two ounces of blood is collected in small glass bottles which are slanted to obtain as long a surface as possible for the serum. The blood is allowed to cool and the bottles are placed in an ice-box to allow the serum to separate from the clotted blood. After twenty-four hours, the serum is inactivated at 55 C. for one hour, passed through a Berkefeld stone filter, and transferred to small sterile bottles. The serum should be free of hemoglobin, red blood cells, or any solid matter. The addition of 0.2 per cent of tricresol has been recommended as a preservative, but others believe that this increases the local irritant action of the serum. In all cases observed in the preparalytic stage, whether epidemic or sporadic in form, an intraspinal injection of serum should be made when there is a clinical picture of poliomyelitis confirmed by lumbar puncture. Sometimes the lumbar puncture may be made so early in the course of the disease that the spinal fluid is negative, and when this occurs, a large dose of serum may be administered by the intravenous or subcutaneous route. In ten or twelve hours another puncture should be made, and if the fluid then shows pathologic changes, an intraspinal injection of serum and another intravenous injection should be made. The serum should be warmed to the body temperature before the injection is made. The amount of serum administered varies according to the intraspinal pressure and the quantity of spinal fluid withdrawn; the amount of serum must never exceed the quantity of fluid withdrawn. In children up to two years of age, 40 cc. of serum are administered intravenously and larger amounts in older patients. A combination of the intravenous and intraspinal methods seems to be the most effective. By the use of both routes it is possible that more serum, which is weak in antibody content, will penetrate into the body and reach the site of the lesion.

Rosenow and his co-workers claim to have prepared a curative serum by injecting strains of the pleomorphic streptococcus into the horse. This serum was also used by Nuzum, but his method of preparation differed from that of Rosenow. The streptococcus has not been generally accepted as the etiologic organism. Furthermore, Nuzum's success in cultivating a streptococcus is most exceptional, as no other bacteriologist has been able to determine the presence of bacteria in

the cerebrospinal fluid. Attempts to produce an antiserum by immunizing the horse with the virus have not been successful. There is also some objection to using serum of animals because of their susceptibility to other diseases. Other investigators who seem to have been successful in producing an antipoliomyelitis horse serum are Neustaedter and Banzhaf. At the present time, it is impossible to judge the efficiency of any type of serum treatment, as the series of cases treated with normal human and animal sera have been so small.

Drug Therapy.—On the whole, drugs seem to be of little value, but are used both as sedatives and to allay pain, and also as a means of arresting the infection of the spinal cord by the pathogenic organism. Morphine, codeine, aspirin, and similar remedies may be used to overcome the pain and restlessness. Among the drugs that have been used to combat infection are adrenalin, urotropine, quinine, and salvarsan. Urotropine has been administered in the acute stage because of its known antiseptic effect on the spinal fluid.

Mechanotherapy.—No massage, nor manipulation, should be attempted during the early stage of initial paralysis. Pain and tenderness may be relieved by the application of heat. The orthopedic treatment should be instituted as soon as the paralysis is observed, and consists of the prevention of deformity with suitable apparatus, the same principles being applied as in affections of the joints. If there is paralysis of the muscles on the anterior aspect of the leg, the foot falls by gravity into the position of equinus and may be fixed in this position. The weight of the bedclothes greatly aggravates the development of this deformity. In order to prevent this deformity, the foot is held at a right angle to the leg by a simple ankle splint or a bivalved plaster cast. Splinting not only prevents deformity but also gives the anterior group of muscles a better chance to recover. Overstretched muscles do not recover their tone and relaxed muscles recover more rapidly; an active muscle may apparently be paralyzed when it is only overstretched, and will become active after immobilization in the relaxed position. In fixed equinus, the anterior group may be feeble or apparently paralyzed until the foot, by severence of posterior structures is placed at a right angle to the leg, relaxing the anterior group, when muscle power is often spontaneously regained and dorsiflexion of the foot in walking is possible. Full extension is the most useful position for the knee. Flexion contractures, extreme hyperextension or rotary or lateral displacements should be prevented. The hips should be held straight and slightly adducted to prevent the common tendency to flexion and abduction. The spine is conveniently

supported in the early stage on a Bradford frame, or if this is not obtainable, a plaster cast may be applied. The spine must be carefully observed until full growth is attained, as deformity may arise in later years, due to the increase in superincumbent weight by normal growth and loss of muscle balance.

When the nervous symptoms have subsided, the third stage, called, for convenience, the stage of resolution or improvement, begins; in almost every case there is some spontaneous return of function. At this time, physiotherapy, consisting of massage, electricity, and muscle training, is indicated in addition to apparatus for the prevention of deformity. Even though the neuromuscular system has returned to normal function, the child has frequently forgotten the use of the affected muscles. Physiotherapy should always be administered by an expert, as much harm may be done by ignorant and inexperienced individuals. If it is impossible to secure trained physiotherapists, the mother or attendant should acquire a knowledge of simple methods of muscle training and massage, and the proper use of electricity. Massage should be started as soon as muscle tenderness has disappeared, and treatment should be given daily. The massage period occupies from five to fifteen minutes, depending upon the extent of the pathology. Massage consists of definite manipulations, including stroking, kneading, friction, and percussion. If the whole body is to be treated, the general course of procedure is massage of the legs, abdomen, arms, shoulders, and back. During massage, the limb should always be kept in good functional position. Treatment by massage should be continued until the circulation is normal and until there are signs of muscular activity. Physiotherapy is of the greatest benefit during the first eight months.

Weight should not be borne on the affected limbs when the lower extremities are involved, as there is danger of overstretching the weak and paralyzed muscles. Three to six months should elapse before weight-bearing is resumed, to permit return of function in the muscles. Parents often permit the child to walk because of the erroneous idea that exercise of the affected muscles alone will cause a restoration to normal. It is most important, however, that the muscles be kept in a state of relaxation, as overfatigue of paralyzed or partially paralyzed muscles tends to cause further deterioration. The development of deformities is progressive in character. The first change to occur is the contraction of the muscles, fascia, and ligaments on the unaffected side, and the relaxation and stretching of the muscles, fascia, and ligaments on the paralyzed side. During and immediately after the paral-

ysis, the limb may be placed easily in the correct position; if, however, the malposition is not corrected, deformity will increase, and in time become structural with actual change in contour of the bones. At this stage, the occurrence of deformity is common, but is inexcusable. The objection that immobilization in apparatus increases atrophy of the limb is not adequate, since any wasting may be overcome by proper therapeutic measures, such as massage and exercise. When the residual stage of paralysis has been reached and no increase in function is apparent, further improvement in muscle power can often be developed, especially in those who have had no previous treatment. This is accomplished by reeducation and training of the muscles which possess active motion, even though it be slight. Muscles in which there is some power may be trained to assume some of their functions by carefully systematized exercise of the affected part, and by general exercise of the weakened limb. Specific group exercises are beneficial during the period of convalescence and general exercise is more effective when the patient is ambulatory. However, if the paralysis is extensive, no approach of normal can be expected from treatment after the residual stage has occurred, which is about two years after the onset of the paralysis.

The application of heat in connection with massage is of advantage, and heat from light rays has been found of greater value than heat secured by other means. The dry form of heat is more effective than the moist because the patient can not tolerate water at such high temperatures. The paralyzed limbs should be kept warm and the patient protected properly against cold by wearing additional clothing, or loosely applied flannel bandages. Whirlpool baths, if properly supervised, may have a beneficial effect upon the local circulation. The elimination of gravity by exercises performed under water is also of value when muscles are too weak to function under normal conditions. The baths used for this purpose may be plain water or salt water, as salt increases the buoyancy of the water. The underwater gymnasium, as suggested by Lowman, may be of great assistance in reeducating the atrophic muscles, but should not wholly replace ordinary massage and muscular exercises.

The application of electricity in the treatment of anterior poliomyelitis is limited. The currents most commonly used are the galvanic and the faradic; a contraction can be elicited in a paralyzed muscle by the galvanic current when it is impossible to obtain a reaction in the muscle by any other stimulus. The faradic current is used to stimulate contraction of a weakened muscle, but since some voluntary power

remains in such cases, functional use of the limb is of more benefit than electricity. Until further proof of its value is submitted, electricity will not be generally accepted as one of the modern methods of treating infantile paralysis.

Braces in the lower extremities may be indicated until sufficient time has elapsed for muscle tone to be restored, or to enable the patient to walk and also to prevent deformity. They should be constructed to conform to the shape of limb, and regulate the range of motion in the joint. In the foot, if there is contraction of the heel cord and equinus, the joint at the ankle must be so constructed that plantarflexion will be prevented, but dorsiflexion will be free. If the reverse is true, the joint is so constructed that dorsiflexion is prevented, and if the joint is practically flail, motion at the ankle can be restricted to a very limited range. At the knee, it may be necessary to prevent motion by holding the knee perfectly still while walking by a catch which can be loosened to permit flexion of the knee in the sitting posture. A stopjoint may at times be necessary to prevent overextension or hyperextension. Also a kneestrap may be necessary in very weak knees to further stabilize the knee. The hip should often be held perfectly stiff until there is no likelihood of further contraction. This joint is most frequently neglected on account of the difficulty of sitting with the hip held in extension by a brace.

Surgical Treatment.—In the residual stage surgical treatment may be indicated to correct deformity, to restore muscle power, and to stabilize loose and relaxed joints. The operations for the correction of deformity consist in forcible correction, osteotomies for the correction of osseous deformity, and tenotomies, tenoplasties or fasciotomies for lengthening contracted soft structures. Large tendons, such as the tendo achillis, may be lengthened by plastic measures. The function of the entire limb must be considered. For example, in fixed equinus, the patient may walk quite well by the tense heel cord holding the knee stable through the gastrocnemius muscle. If the cord is made too long, the foot may become flail and the knee unstable, thus rendering the extremity weaker, walking difficult, and the patient more disabled than before correction was attempted.

Operations for the restoration of muscle power consist of nerve anastomosis and tendon transplantation. Nerve anastomosis which consists in transferring portions of normal nerves into those supplying paralyzed muscles, has not proved satisfactory, and is of historical interest only. Tendon transplantation is a valuable procedure when employed in selected cases. While brilliant results have been obtained

by this method, many failures have also occurred, probably due to the lack of correct technic. The tendon of an active muscle is transferred to the point of insertion of a paralyzed muscle. The transplanted muscle must be of sufficient power to perform the function of the muscle whose action it assumes, and be correctly placed and arranged in the new position so that it will be capable of assuming the function of the replaced muscle.

Operations for stabilization consist of surgical arthrodesis or ankylosis of joints by operative methods. Certain operations have been devised by which the part is made stronger and more useful by correction of deformity, stabilization, and restoration of function. Surgical procedures for the reconstruction of a paralyzed extremity must be planned along correct mechanical lines. The position of the foot and its relation to the other portions of the limb must also be considered. Operations which require the removal of bone for the purpose of fusion, stabilization or reconstruction, are contra-indicated in very young children and should not be attempted before the age of eight years, or until there has been sufficient osseous development.

Operations on Foot and Ankle in Poliomyelitis

The object of surgical procedures upon the foot and ankle is to restore an even distribution of weight on the sole of the foot and thus afford a stable foundation to the body. Deformity can be corrected in most cases of paralytic feet by excision and remodeling of three joints: the astragaloscaphoid, the calcaneocuboid, and the subastragalar. The joints may be fused separately or resection of all three may be necessary. When the astragaloscaphoid or the calcaneocuboid joints are arthrodesed a more accurate approximation can usually be obtained, if both joints in the midtarsal region are remodeled at the same time. Since all lateral motion in normal feet and in most paralytic feet occurs in the subastragalar joint, arthrodesis of this joint is necessary to prevent lateral deviation. Various modifications of the technic have been described by Davis, Dunn, Ryerson, Hoke, and others, the principles of which are essentially the same.

Arthrodesis.—An incision is made from the external malleolus to the base of the fifth metatarsal bone. The extensor digitorum brevis muscle is exposed and its origin from the anterior portion of the os calcis is divided. By retraction of the extensor muscles and tendons to the inner side of the foot, the dorsal surfaces of the tarsal bones are fully exposed; a section of bone including the articular surfaces is removed from between the os calcis and the cuboid with a sharp

osteotome. The head and a varying portion of the neck of the astragalus are removed and also a part or the entire scaphoid bone. If the scaphoid is completely excised the cartilage covering the proximal surfaces of the cuneiform bones is resected. The external contour of the foot as well as the osseous surfaces within the wounds must be inspected. A greater mass of bone is removed from the inner side than from the outer side of the foot and when the operation is completed the foot is shortened, the arch should be symmetrical and the weight-bearing line should be through the center of the astragalus. An accurate approximation of the osseous surfaces is important, but osteogenesis is stimulated and fusion produced more rapidly if the apposing bony surfaces are roughened by strokes of the osteotome and numerous particles of spongy bone placed between the bones than if the surfaces are made smooth and regular.

If arthrodesis of the subastragalar joint is required, the joint may be exposed through the same incision. The soft structures are stripped from the bones, the ligaments divided and the joint defined. A transverse section is made between the astragalus and os calcis removing the cartilaginous surfaces of the bones. After free dissection about the internal and external malleoli, the foot may be displaced backward beneath the astragalus. The surfaces of the bones are likewise roughened, the foot placed in the most satisfactory position for weight bearing, *i. e.*, in slight valgus and equinus, and the wound closed in layers. A plaster cast is applied and worn for two or three months to maintain the position. When the cast is removed, an ankle brace is fitted and walking permitted. The brace is worn during the day and a splint at night until fusion, as demonstrated by the roentgenogram, is solid.

Drop Foot Operation.—The arthrodesis of the midtarsal and subastragalar joints corrects lateral deformity and instability, but does not prevent the falling forward of the foot (drop foot) when there is paralysis of the anterior group of muscles of the leg. The author has devised an operation for the correction of drop foot which consists of transplanting a mass of spongy bone into the upper surface of the os calcis in close proximity to the ankle joint. This new bone lives, fuses with the os calcis, and forms a process which impinges upon the posterior surface of the tibia and prevents plantarflexion. The procedure is usually combined with triple arthrodesis and thus has the advantage of stabilizing anteroposterior as well as lateral motion, and also conserving the rocker motion of the ankle joint. The skin incision is made over the Achilles tendon, if this structure is contracted; other-

Fig. 424.—Z-shaped incision for lengthening tendo achillis.

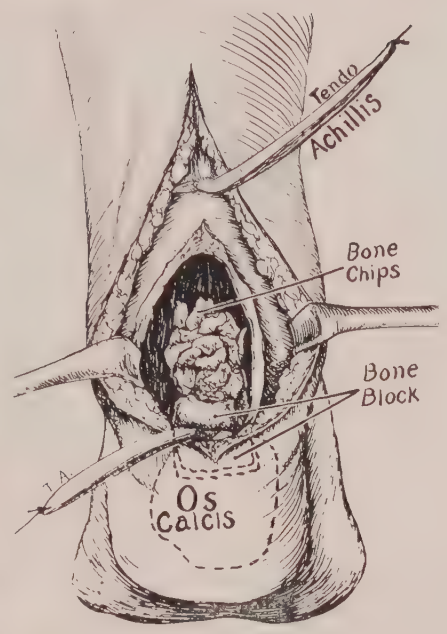


Fig. 425.—Technic of drop foot operation, illustrating the tendo achillis lengthened by Z-shaped incision and mass of bone chips transplanted to upper surface of os calcis.

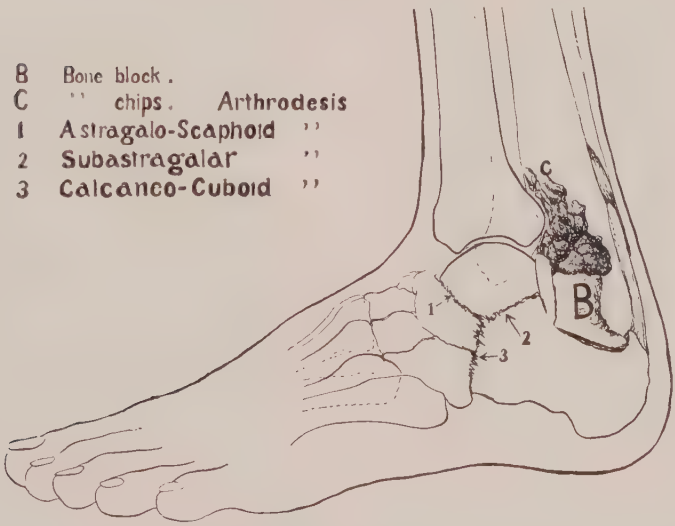


Fig. 426.—Result of triple arthrodesis and drop foot operation. Note fusion of calcaneocuboid, astragaloscaphoid, and subastragalar joints and mass of bone on os calcis.

wise to the outer or inner side, as is convenient. It should extend from the superior aspect of the tuberosity of the os calcis upward for 3 or 4 inches in a straight line. If the Achilles tendon is contracted, a

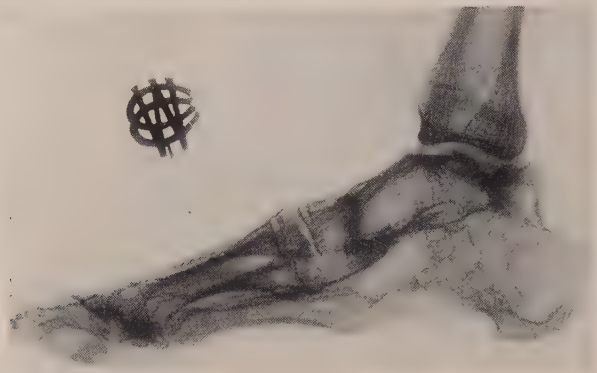


Fig. 427.—Foot following arthrodesis of astragaloscaphoid, calcaneocuboid, and subastragalar joints and drop foot operation.

severance is made by the Z-shaped plastic method. A straight incision is next made in the midline to the posterior surface of the ankle joint, tracting inward the tendon of the flexor longus pollicus. With a heavy

Fig. 428.—Talipes equinovarus.

Fig. 429.—Same as Fig. 428, after drop foot operation. Note foot blocked at right angle.

periosteal elevator, a pyramidal space is cleared, exposing the posterior surface of the tibia, ankle joint, subastragalar joint, and superior surface of the os calcis. The foot is dorsiflexed, bringing into view

the posterior extremity of the astragalus for $\frac{1}{2}$ to $\frac{3}{4}$ inch. This portion of the astragalus is removed, and a wedge-shaped cavity is excavated on the os calcis, below the posterior extremity of the astragalus, and the posterior portion of the articular surface of the tibia. Bone may be transplanted from any portion of the skeleton. As it is usually necessary to enter the forefoot for the purpose of stabilization by arthrodesis, bone is often excised and may be utilized for transplantation. Transplants from the femur, when the case is complicated by genu valgum, and from the ilium, in transferring the crest in hip flexion contractures, have proved efficient. If bone is excised from the forefoot, it is denuded of cartilage and a large piece, about $\frac{1}{2}$ inch in diameter, is selected and placed in the cavity prepared on the superior surface of the os calcis, about which small particles are arranged in a pyramidal shape. The cartilage removed is placed in mosaic fashion to cover the posterior, inner, and outer aspects of the pyramid, and to prevent adhesion to surrounding structures; this step, however, is by no means essential, as the results are as good when bone is obtained elsewhere, without cartilage. The soft tissues are sutured snugly to retain the transplants in situ, the Achilles tendon is united if severance had been required, and the fascia and skin are closed. The foot is then held by a plaster cast at an angle of 90 degrees with the leg. The technic may be modified when the forefoot is stable, by turning forward the upper third of the os calcis. In performing a triple arthrodesis, it is also possible to transfer particles of bone from the midtarsal region through the subastragalar joint to the superior surface of the os calcis, but the block cannot be so accurately placed as when the posterior incision is employed.

Astragalectomy, described by Whitman, is a valuable procedure in flail foot and talipes calcaneovalgus. The original technic has been somewhat modified by the author. An incision is made on the anterolateral aspect of the foot internal to the fibula, from 2 inches above the ankle to the cuboid bone below, and, if necessary, extended above and below. This incision can be continued directly down through the soft tissues to the bone, for there are no important structures to consider, as the incision is external to the extensor longus digitorum tendons and all vessels and nerves. All ligamentous attachments about the head of the astragalus are severed, and the subastragalar joint freed, after which the astragalus may be grasped by heavy forceps and dissected loose from all attachments. The cartilage on the articular surface of each malleoli is removed. Small areas on the inner and outer surfaces of the os calcis are denuded just posterior to the anterior

extremity. The foot is then displaced backward, so that the raw surfaces of the malleoli come into contact with raw surfaces of the os calcis. The os calcis is thus placed between the malleoli articulating with the articular surface of the tibia. The wound is then closed in routine manner and a plaster cast applied with the foot in moderate equinus. The cast is changed in three weeks to ascertain if there is perfect position of the foot with backward displacement. The anterior incision is of distinct advantage, healing more rapidly than the incision below the external malleoli. Furthermore, the approach is satisfactory. The result may be a movable joint with just sufficient motion to give elastic-

Fig. 430.—Foot five years after astragalectomy. Note backward displacement of foot on tibia.

ity in walking, about 20 to 30 degrees, or there may be complete ankylosis and fusion between the tibia and os calcis with no motion, but increased compensatory motion of the midtarsus. The appearance of the foot may be practically normal and there may be normal endurance.

Hoke's Operation.—The operation described by Hoke consists of stabilizing the subastragalar and astragaloscaphoid joints and correcting the posterior deformity of the foot at the same time. The skin incision extends from over the external portion of the head of the astragalus downward and backward to the peroneal tendons below the end of the fibula. The adipose tissue of the subastragaloid fossa, that is, the space bounded above by the neck of the astragalus, below by the superior

surface of the os calcis, and behind by the body of the astragalus, is split. Its upper and lower portions are dissected out, leaving the under surface of the neck and the adjacent portion of the body of the astragalus and the superior surface of the os calcis bare. With a knife the superior surface of the neck of the astragalus is denuded of tissue. The head of the astragalus is freed from the scaphoid by first cutting the astragaloscaphoid ligament, then beginning low and externally and sweeping around the head, ending internally. A portion of the inferior surface of the body of the astragalus and a portion of the adjacent surface of the os calcis are removed. The neck of the astragalus is cut through where it joins the body. The head of the astragalus is levered partially out, and the remaining attachments are cut with scissors. The neck and head of the astragalus are placed in a towel. The scaphoid and the facet on the superior surface of the os calcis are denuded of cartilage. The posterior foot deformity may now be corrected as required; the posterior end of the os calcis may be set in line with the center of the leg, the os calcis may be shifted laterally in line with the central axis of the leg, lateral rotation of the os calcis may be corrected, and the foot may be shifted backward. The head of the astragalus is denuded of cartilage. The position in which the astragalus is replaced depends upon the type of paralytic foot; it is put back in a different position for drop foot, clubfoot, and flatfoot. After the astragalus has been replaced, the foot is brought into slight dorsiflexion. The wound is closed and a plaster bandage is applied from the toes to the knee.

Steindler's Operation.—Steindler has described an operation to correct cavus deformity following paralysis or other affections of the foot. A horizontal incision is made over the inner aspect of the os calcis forward, reaching to a point $1\frac{1}{2}$ inches in front of the inner tubercle of this bone. When the skin and fat are divided, the lower or plantar surface of the plantar fascia is separated from the layer of fat and freed throughout its entire width. The fascia is then incised crosswise close to the point where it blends into the lower surface of the os calcis. The muscles covered by the plantar fascia are, from within outward, the abductor of the big toe, the short flexors of the toes, and the abductor of the fifth toe. These muscles are stripped off the periosteum of the os calcis with a blunt instrument and it is necessary to extend the stripping forward to the calcaneocuboid junction in order to reach and strip off the long plantar ligament which extends between the os calcis and the cuboid bone. The ligament is often contracted, and if so, produces a convexity of the foot at the outer border. By keeping close to the bone in stripping one is at a safe distance from the plantar vessels and nerves. When

stripping has been completed, the correction of the foot is accomplished by wrenching; in severer cases bone operations may be necessary, the extent of which depends upon the degree of the skeletal deformity. None of the cortical bone from the os calcis should be removed when the stripping is done. Unless this point is observed bone formation may occur on the plantar surface of the foot. This complication need not occur, however, if a blunt instrument is used, or the muscles separated close to the periosteum with a knife instead of scraping sharply with a keen-edged chisel.

Tendon Transplantation.—The purpose of tendon transplantation is to replace a paralyzed muscle by a normal muscle that is physiologically adapted to act as a substitute. Tendon transplantation in the treatment of infantile paralysis was first performed by Nicoladoni in 1882. The method, while extensively used at one time, has not proved universally satisfactory. Such procedures as the insertion of long strands of silk and other suture materials are mentioned only to be condemned. The only transplantation in the foot that gives uniformly good results is the transference of the anterior tibial tendon to the cuboid bone on the outer side of the foot for talipes varus. Stabilizing operations on the feet may often be advantageously combined with tendon transplantation.

An incision, about 2 inches long, is made over the attachment of the anterior tibial tendon, beginning about 2 inches above its insertion. The tendon sheath is split and the attachment of the tendon exposed. The tendon is severed at its insertion, and if possible, the operator takes with the tendon a bit of its bony attachment. A 2-inch incision is made over the anterior tibial muscle, beginning about 4 inches above the ankle joint. A semicircular incision is made over the cuboid bone. The skin and fascia are elevated. A similar incision is made into the tissue of the cuboid bone with the flap pointing in the direction of the anterior tibial tendon. By means of a blunt dissector, the whole tendon is pulled through its sheath and drawn out of the second wound. The end of the tendon is quilted with chromic catgut or linen. A pair of forceps is introduced into the cuboid wound and passed under the skin and fascia to the incision over the tibia. The sutures and the end of the anterior tibial tendon are grasped and pulled into the cuboid wound. If desired, the anterior tibial tendon may be transferred through the sheath of the extensor longus digitorum. The sheath of the anterior tibial tendon is closed with continuous fine catgut. The first two skin wounds are closed with continuous catgut. The suture attached to the tendon is passed by means of a hook into the cavity made in the cuboid bone and brought

out through the periosteum. The remaining suture is passed through the body of the cuboid bone, coming out on the opposite side. The foot is placed in an overcorrected position. The sutures are pulled tightly, bringing the tendon into the cuboid cavity. The skin is closed and a plaster bandage is applied from the toe to just above the knee, with the foot held at a right angle and in the position of valgus. After six weeks the cast is split to allow the foot to receive local treatment. Passive and active movements are begun early, and as soon as sensitiveness has subsided, weight bearing on the cast is encouraged. Plaster bandages are worn for eight to ten weeks, changes being made, if necessary, after the third or fourth week. Upon the removal of the last plaster bandage, a varus brace is applied and worn for about six months. Later, an elevation on the outer side of the sole of the shoe assists in maintaining correction. It is well to maintain the foot in overcorrection and prevent any strain on the transplant for one year.

Operations on Knee in Poliomyelitis

Division of the posterior capsule of the knee joint, as described in the section on Infectious Arthritis, combined with tenotomy of the hamstring tendons and contracted bands in the fascia lata, may be required to correct flexion contracture of the knee joint. Osteotomy of the femur through or just above the condyles may be necessary to correct flexion contracture, genu varum, or genu valgum. Even slight flexion materially weakens the knee; if the weight is borne in a perfectly straight line, or a slight recurvation, walking is greatly facilitated. Severe deformities of the knee, as flexion contractures with subluxation of the tibia, should be corrected gradually by apparatus. If some degree of correction can thus be obtained before operation, much bone may be conserved.

Tendon Transplantation.—Transference of the hamstring tendons into the quadriceps tendon or patella in paralysis of the quadriceps muscle is a valuable procedure. There are several muscles available for transplantation; the biceps, the semitendinosus, the semimembranosus, or the sartorius may be employed. The author believes that the biceps lends itself not satisfactorily to transplantation. The sartorius muscle fortunately escapes paralysis in most instances. The tensor vaginae femoris is another muscle available, but as it adds external support to the knee, it is better not to use it unless the indication is imperative. One or both hamstrings may be used, but care must be taken to leave one good flexor in the thigh and to make sure that the gastrocnemius muscle, which also acts as a knee flexor, is functioning. The after-treatment in tendon transplantation at the knee is important. Par-

ticular care should be taken to avoid strain by protecting the limb for at least six months; a plaster cast is worn for six weeks following the operation, and braces or other forms of protection are worn during the remaining period. Three weeks after the operation, weight bearing in the cast is permitted. Six weeks after the operation, physiotherapy, including massage, gentle manipulations, and exercises, is begun.

Arthrodesis of the Patella.—A mild degree of genu recurvatum is often of advantage, but if extreme genu recurvatum is present, the author transplants the patella into the upper extremity of the tibia to limit the forward motion of the leg at the knee. A longitudinal or transverse incision is made over the insertion of the patellar tendon. The attachment of the tendon is removed and a shallow depression made on the upper surface of the tibia. The lower one-third or one-half of the

Fig. 431.—Fusion of patella to tibia in author's operation for genu recurvatum.

patella is denuded of cartilage and tendinous attachments, and this portion of the bone placed in contact with the denuded area of the tibia. This position is maintained by suturing the remainder of the patellar tendon to the periosteum of the tibia and to the capsule of the knee joint. A stop-joint is thus formed blocking hyperextension. The wound is closed and the leg immobilized in a cast, the knee being slightly flexed, for a period of three or four months. Walking is then permitted in a brace which allows flexion but prevents hyperextension.

Operations on the Hip in Poliomyelitis

In the hip, flexion with abduction is a very common and disabling deformity, and often prevents walking, especially if both hips are af-

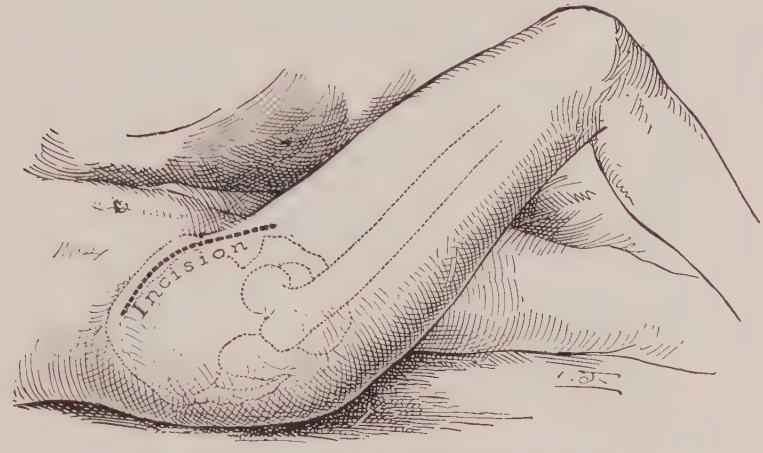


Fig. 432.—Incision for transference of crest of ilium.

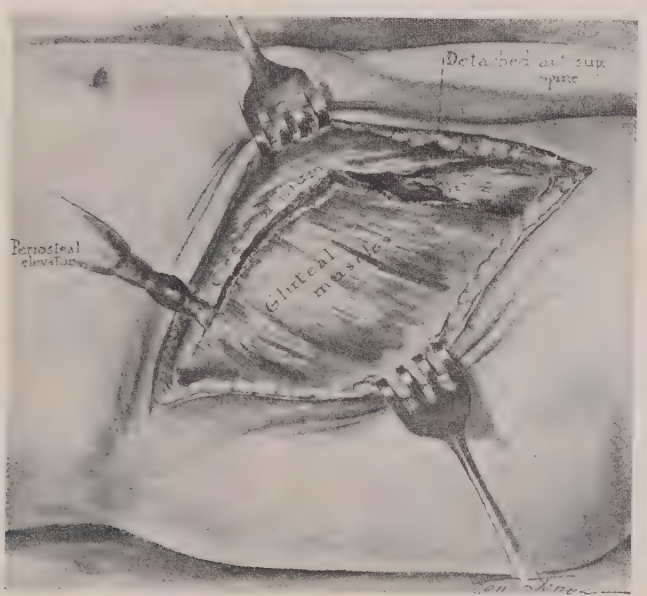


Fig. 433.—Detachment of anterior superior spine and outer margin of crest of ilium.

fected. Transference of the crest of the ilium is the operation employed by the author in this condition, which often enables patients who have been confined to a rolling-chair to assume an upright posture and walk.

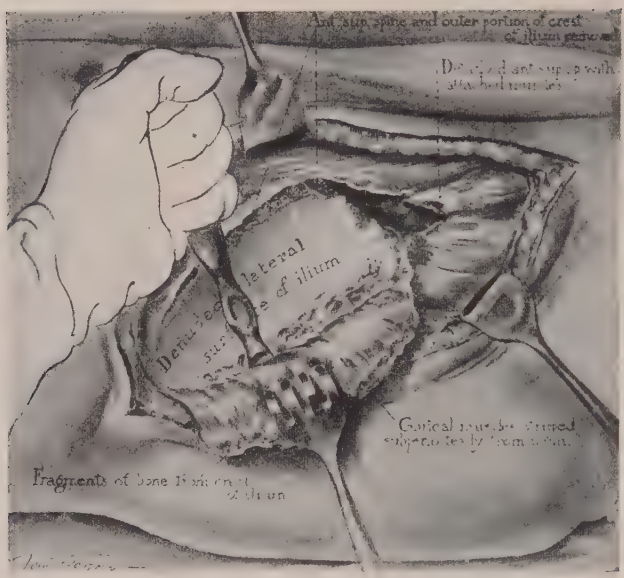


Fig. 434.—Muscles stripped from ilium, allowing extension of hip. Lateral surface of ilium denuded.

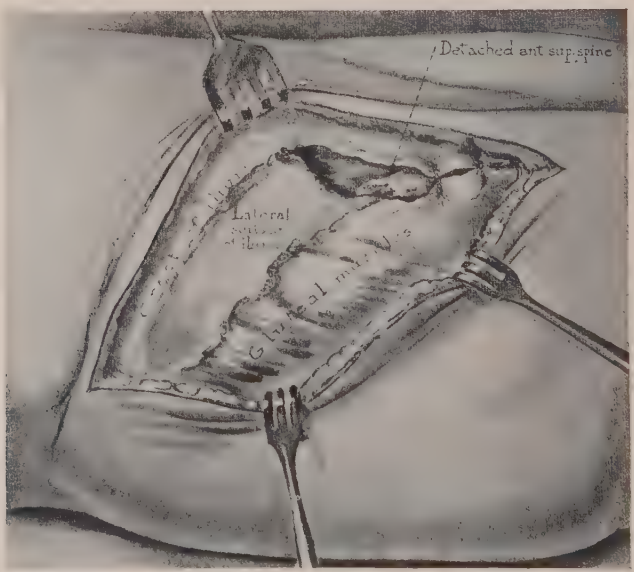


Fig. 435.—Anterior superior spine and detached muscles transplanted to a lower level.

Transference of the Crest of the Ilium.—The skin is incised along the anterior one-half or two-thirds of the crest of the ilium to the anterior superior spine and then downward to the outer aspect of the rectus femoris muscle for about 2 to 4 inches. The superficial and deep fascias

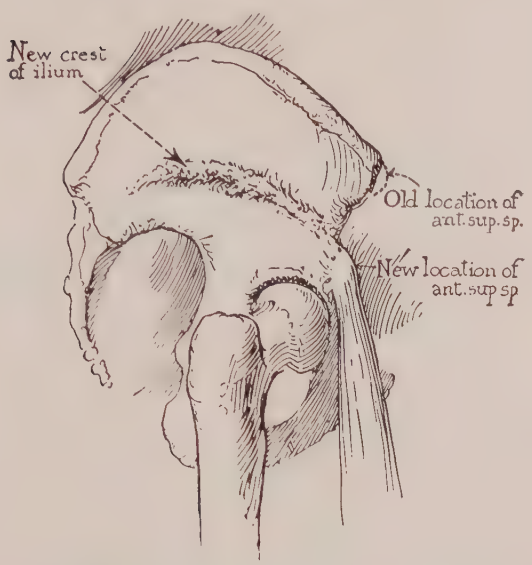


Fig. 436.—Result of transference of crest of ilium.

Fig. 437.—Flexion contracture of hip.

Fig. 438.—Same as Fig. 437, after transference of crest of ilium.

are incised to the crest and anterior superior spine. With a sharp osteotome the anterior superior spine is removed. The outer one-fourth of the crest is chiseled through from before backward, or the anterior two-thirds, or the entire crest, as the occasion demands, after which a heavy osteotome peels the entire mass subperiosteally downward to the rim of the acetabulum, above which a tract of bone is denuded about 1 inch wide and parallel with the crest of the ilium. The raw surfaces of the transferred crest of the ilium and anterior spine fall, by gravity, so that the bony surfaces are approximated. If this does not reduce flexion, the anterior structures, such as psoas, fascia or capsule of the hip joint, may be easily attacked. The superficial fascia on the upper side of the incision is stitched to the deep fascia on the lower side, bringing the skin incision about 1 inch below the crest of the ilium, and thus avoiding possible pressure. The skin is closed with dermal sutures. A spica cast is applied with the hip extended and the position maintained for two to three months.

Fig. 439.—Flexion contracture of hips.

Fig. 440.—Same as Fig. 439, after correction by transference of crest of ilium.

Operations on the Spine in Poliomyelitis

Paralytic scoliosis is described in the treatment of Static Deformities. The spine should be corrected as much as possible and held in the corrected position by apparatus or ankylosing operations.

Operations on the Shoulder in Poliomyelitis

Arthrodesis of the shoulder is a very valuable procedure when the deltoid muscle is paralyzed and the scapular muscles are active. In

Fig. 441.—Amount of adduction of arm following arthrodesis of shoulder in anterior poliomyelitis with paralysis of deltoid muscle.

this manner compensatory shoulder motion may be developed by the muscles of the scapula. The technic is similar to that described in the section on Tuberculosis of the Shoulder Joint.

Operations on the Elbow in Poliomyelitis

Flail elbows with active flexors of the fingers may be greatly benefited by the ingenious procedure devised by Steindler, which consists in transferring the origins of the flexor muscles from the inner condyle of the humerus, with a portion of the condyle, and attaching them to the shaft of the humerus higher up. In this manner, the flexors of the forearm are also used to flex the elbow, and often considerable power is developed at the elbow.

Steindler's Technic.—An incision is made at the inner side of the humerus beginning 3 inches above the internal epicondyle. This incision runs between the brachialis anticus and the triceps muscles downward to behind the internal epicondyle, turns forward and runs obliquely downward and outward on the volar side of the forearm following the

course of the pronator radii teres. The fat and fascia are dissected and the ulnar nerve is located behind the internal epicondyle and drawn backward. The origin of the flexor muscles of the forearm at the internal epicondyle is carefully defined and dissected out, and the muscles detached from the bone close to the periosteum in one mass, which combines the superficial head of the pronator radii teres, the flexor carpi radialis, and the palmaris longus, as well as the flexor carpi ulnaris. These muscles may be stripped down as far as 1 to $1\frac{1}{2}$ inches from the internal epicondyle, at which point the nerve supply from the median nerve enters the muscles. The muscle flap is lifted up and transplanted upward about 2 inches above the epicondyle into the intermuscular septum which divides the triceps muscle from the brachialis anticus, or into the periosteum of the humerus. This is done by strong sutures which fasten the muscles to the septum or periosteum. After the wound is closed in layers the arm is held in acute flexion and in a position midway between pronation and supination. In this position a cast is applied. It is removed after two weeks when the wound is healed and is immediately supplanted by a splint which holds the arm in the same position. This flexed position is to be maintained for at least two months longer. The after-treatment begins after the removal of the cast and consists in active motion, careful massage, and muscle training.

Operations on the Wrist in Poliomyelitis

The wrist, if flail with no use of the fingers, is beyond redemption; but if there are excellent finger flexors, the wrist may be arthrodesed in dorsiflexion and in this position the hand will be restored to a measure of usefulness. In selected cases, tendon transplantation is possibly more efficient in the hand than elsewhere, as weight bearing is not required. Transplantation of the radial and ulnar flexors to the posterior surface of the wrist is of special value. Dorsal flexion of the hand is thus restored and drop wrist overcome.

BIBLIOGRAPHY

Aycock, G. F., and Eaton, P.: Epidermiology of Infantile Paralysis, Amer. Jour. Hyg., 5: 724, 1925.

Campbell, Willis C.: An Operation for the Correction of Drop-Foot, Jour. Bone and Joint Surg., 5: 815, 1923; End Results of Operation for Correction of Drop-Foot, Jour. Amer. Med. Assoc., 85: 1927, 1925.

Ibid.: Transference of the Crest of the Ilium for Flexion Contracture of the Hip, Southern Med. Jour., 16: 289, 1925.

Charcot, J. A., and Jaffray, A.: Cas de paralysie spinale avec lesions des cornes antereures de la substance grise de la moelle epiniere Arch. de physiol. norm. et path., 10: 134, 1870.

Cornil, V.: Paralysis Infantile, Compt. rend. d. Soc. de biol., 5: 187, 1863.

Davis, G. G.: Treatment of Poliomyelitis by Operative Measures, New York Med. Jour., 119: 4, 1914.

Dunn, N.: Stabilizing Operations in Paralytic Feet, Proc. Roy. Soc. Med. (Sect. Orthop.), 15: 15, 1922.

Flexner, S., and Noguchi, H.: Experiments on the Cultivation of the Microorganism Causing Epidemic Poliomyelitis, Exper. Med., 18: 461, 1913.

Hoke, M.: An Operation for Stabilizing Paralytic Feet, Jour. Orthop. Surg., 3: 494, 1921.

Lowman, C. L.: The Underwater Gymnasium as an Adjunct to Orthopedic Surgery, Jour. Bone and Joint Surg., 9: 119, 1927.

Medin, O.: Ueber eine epidemic nu spinaler Kinderlahmung, Verhandl. d. Internat. Med. Cong., Berlin, 2: 27, 1891.

Netter, A.: Serotherapie de la poliomyélite, Arch. de med. d. enf., 29: 1, 1916.

Neustaedter, M., and Banzhof, E. J.: An Antipoliomyelitis Horse Serum, Jour. Amer. Med. Assoc., 68: 1531, 1917.

Nuzum, J. W.: Antipoliomyelitis Serum, Jour. Amer. Med. Assoc., 68: 24, 1917; Specific Serotheraphy of Poliomyelitis, Jour. Amer. Med. Assoc., 69: 1247, 1917.

Prevost, M. J. L.: Observation de paralysie infantile, Compt. rend d. Soc. de biol., 17: 215, 1865.

Rosenow, E. C.: Treatment of Acute Poliomyelitis with Immune Horse Serum, Jour. Amer. Med. Assoc., 77: 588, 1921.

Rosenow, E. C., Towne, E. B., and Wheeler, G. W.: Observations on Immunity of Monkeys to Experimental Poliomyelitis, Jour. Amer. Med. Assoc., 68: 280, 1917.

Ryerson, E. W.: Arthrodesing Operations on the Feet, Jour. Bone and Joint Surg., 5: 453, 1923.

Shaw, John: On the Nature and Treatment of the Distortions to which the Spine and the Bones of the Chest are Subject, London, Langman, 1823–24.

Steindler, A.: Operative Orthopedics, New York, D. Appleton and Co., 1925, pp. 43, 98.

Underwood, Michael: Treatise on the Diseases of Children, Philadelphia, T. Dobson, 1793.

Von Heine, Jacob: Beobachtungen über Lahmungszustande der untern Extremitaten und deren Behandlung, Stuttgart, 1840.

Whitman, Royal: Astragalectomy, Orthopedic Surgery, Ed. 6, Philadelphia, Lea and Febiger, 1919, p. 808.

Wickman, I.: Studien über Poliomyelitis acuta, Arb. a. d. path. Inst. d. Univ., Helsingfors, Berlin, 1: 109, 1905.

CHAPTER XVI

AFFECTIONS OF THE NERVOUS SYSTEM (*Continued*)

SPASTIC CEREBRAL PARALYSIS

(Little's Disease)

Spastic cerebral paralysis is caused by a destructive lesion in the cortex of the brain and is characterized by paralysis, spasticity, and incoordination of the muscles. The extent and distribution of the paralysis depend upon the location and area of the brain injury. One extremity may be involved, producing a monoplegia; the arm and leg on one side, a hemiplegia; both legs, the arms being normal, a paraplegia; or all four extremities, a quadriplegia. In severe cases the muscles of the face and trunk are usually also involved.

Etiology.—The paralysis is caused by disease of or injury to the cerebral cortex which results in partial or complete destruction of the ganglionic cells in the motor area. The entire cortex of the brain may be, and often is, similarly involved, as is shown by the frequent impairment of the general mentality, which varies from normal in the mild cases to complete idiocy in the more severe types. When the motor cells are destroyed, the muscles which they supply are kept in a state of hyperexcitability or activity by the sensory impulses reaching them through the lower reflex arc. The disease may be prenatal in origin, but usually dates from birth; the majority of the patients are firstborn children or those delivered by the use of forceps, and are at birth asphyxiated. In rare instances, the paralysis may occur in infancy or early childhood in association with the common infectious diseases. When the damage occurs before birth, the cause may be an inflammatory disease, as poliencephalitis, a congenital malformation of the brain, or a primary degeneration of the motor cells, the exact nature of which is unknown. Spastic paralysis is apparently associated with premature birth. It has been definitely proved that the pyramidal motor tracts are not fully developed until the eighth month of fetal life; consequently, disturbance of development with loss of motor control might be expected in six- or seven-month babies. It is also probable that both the brain degeneration and the premature birth are part of and caused by the same undetermined cause.

Birth palsies are most frequently the result of meningeal hemorrhage or laceration of the brain tissue. The hemorrhage is produced by rupture of the cerebral vessels as the child is molded in its passage through the birth canal. The bleeding may come from the veins or from the longitudinal sinuses and is more common in breech deliveries and difficult forceps extractions. Recent investigations based on postmortem examinations and careful birth histories have shown that intracranial hemorrhage in the newborn is much more common than has been previously thought. Slight hemorrhages occur in about 15 per cent, severe hemorrhage with cyanosis, convulsions, and permanent brain injury in 2 per cent, and fatal hemorrhages in about 1 per cent of all deliveries. The onset of the postpartum paralysis may closely resemble that of anterior poliomyelitis; it often begins with an acute illness during the first decade of life. Hemiplegias may occur in association with such diseases as measles, scarlet fever, diphtheria, encephalitis lethargica, and infections of the middle ear and mastoid. Rarely, spastic paralysis may be the result of an attack of anterior poliomyelitis when the infection localizes in the motor area of the cerebral cortex. Frequently the paralysis follows a fall or a slight blow on the head. Primary vascular disease, such as arteriosclerosis, is the usual cause of apoplexy in adults, but is of rare occurrence in children. The presence of congenital syphilis as an etiologic factor has not been substantiated by either clinical or laboratory investigation.

Pathology.—The pathologic findings consist of a general atrophy of the brain with shrinkage and sclerosis of the convolutions or localized areas of softening and degeneration. The dura is usually free and of normal thickness, although occasionally areas of thickening and adhesions are found. The cortex of the brain is most often smooth, especially in the diplegias; in hemiplegia it is common to find the arachnoid thickened with numerous subarachnoid cysts, varying in size from one to several centimeters in diameter. There is degeneration of the pyramidal tracts and the lateral columns of the spinal cord. The cerebrospinal fluid is clear and under normal tension. Microscopically, the atrophied cortex shows an absence of ganglion cells and nerve fibers, the nerve tissue being replaced by gliosis.

Symptoms.—Many cases give a normal birth history; however, there is often a difficult delivery, followed by cyanosis and convulsions. The postnatal cases usually appear as a sudden paralysis involving one or both sides of the body, during the course of some infectious disease. The paralysis is called to the parents' attention by the child's inability to control the movements of the extremities; the child is slow in sitting

up, walking, and talking. The spasticity is increased by any attempt to use the limb; the muscles are excited by passive manipulation, but are relaxed during sleep. Certain muscle groups, such as the adductors of the thigh, the flexors of the knee, and the calf muscles forming the tendo achillis, are more powerful than their antagonists. In conditions of general muscular spasticity, where voluntary control is lost, these muscle groups overcome their weaker antagonists, draw the limbs into position of deformity and prevent walking. In milder cases, particularly

Fig. 442.—Spastic paralysis with adduction of thighs, flexion of knees and contracture of tendo achillis.

Fig. 443.—Same as Fig. 442, after Stoffel operation and correction of deformities.

the hemiplegias, there may be only a slight awkwardness in the use of the hand, a turning in of the toes, and a tendency to drag the foot. The reflexes are usually exaggerated. The Babinski sign is positive, and the extremities may be in a state of constant irregular movement. The mental condition is as a rule defective, the more severe cases being hopeless idiots, dribbling saliva, with expressionless faces and small underdeveloped heads. Epileptic attacks are common, appearing, as a rule, two or three years after the paralysis, but may be delayed

for ten or even thirty years. As the child grows older, fixed deformities develop, due to permanent shortening of the overactive muscle groups; the most common of these are the contracture of the tendo achillis, flexion of the knees, and adduction of the thighs. In cases of long standing, the growth of the bones may be retarded. The muscular atrophy is usually not so great as in anterior poliomyelitis.

Diagnosis.—Spastic cerebral paralysis is often confused with anterior poliomyelitis. In the former, however, the history is almost pathognomonic; the condition exists from or shortly after birth; the muscles of one or more extremities are spastic and the mentality may be impaired. The reflexes are abolished in infantile paralysis and hyperactive in spastic paralysis. The muscles are flaccid and atrophied in infantile paralysis and rigid and well developed in spastic paralysis. The mentality is never impaired in infantile paralysis, and there is no incoordination or jerking of the extremities. Sensation is normal in both conditions. In Mongolian idiocy the facial expression is characteristic, the muscle tone is normal, without spasticity or hyperactivity of the reflexes, and the child has voluntary control of the extremities. Lateral amyotrophic sclerosis has similar physical findings, but the history of a gradually progressive disease, coming on usually after the first decade, differentiates it from spastic paralysis, which is present at or appears soon after birth, and tends to improve as the child grows older. In spina bifida, the roentgenogram will show a defect in closure of the spinous processes of the vertebrae, and a meningocele may be present. Disturbance of sensation in the extremities is present in spina bifida and absent in spastic paralysis.

Prognosis.—The prognosis should be guarded as restoration of function depends upon the extent of the central lesion. Gradual spontaneous improvement is to be expected, except in those with marked mental deficiency. In mild spasticity, normal function may often be secured by appropriate treatment and even severe cases may be greatly benefited.

Treatment.—Medicinal treatment, including the administration of glandular products, such as pituitary and thyroid extracts, has proved of little value. The fundamental cause of the paralysis is the destruction of the motor ganglion cells in the cortex of the brain and nothing can be done to replace them. However, the function of the extremities can be materially improved by correcting the spasmodic or fixed contractures. Various operative procedures have been employed to correct these deformities. The surgical treatment may be divided into (1) operations upon the central nervous system; (2) operations upon the

peripheral nerve, and (3) operations upon the tendons and muscles. Decompression has been advocated with the idea of relieving intracranial pressure, but little benefit is derived from the operation, as might be expected from a study of the true pathologic condition. Förster attempted sectioning of the sensory nerve roots within the spinal canal as they emerged from the spinal cord. This operation has been abandoned, because of the high operative mortality and the uncertainty of the results. Sympathetic ramisection, as advocated by Royle, aims at removal of the immodulated nerve impulses sent out from the cerebellar centers to the peripheral nerves and muscles through the sym-

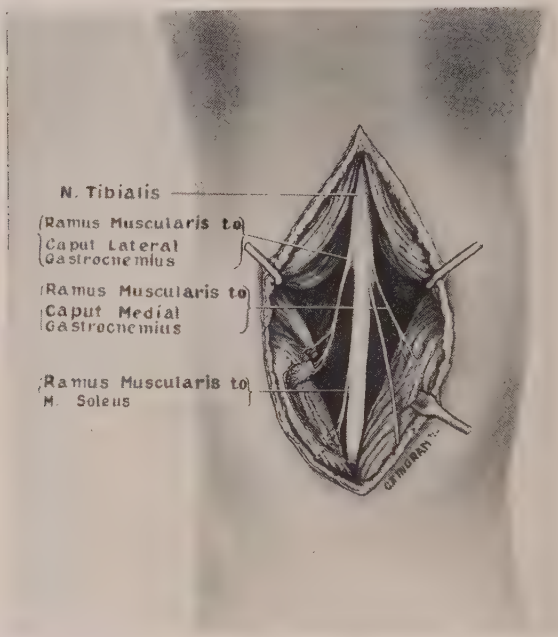


Fig. 444.—Branches of tibial nerve which are resected in Stoffel operation to relieve spastic contracture of foot.

pathetic nerve fiber. The sympathetic ganglion are exposed in the cervical or lumbar region according to whether the operation is planned to relieve spasticity in the upper or lower extremity and the nerve fibers divided. This operation is still in the experimental stage, is quite radical, and the results do not justify its use as a routine procedure.

The motor nerves offer the most logical point of attack, and the operation advised by Stoffel is the most direct and accurate method of cutting down the excessive stimuli. The motor fibers may be identified within the main nerve trunk or the branches to the muscles may be

isolated after they leave the parent trunk, just before they enter the muscles. Practically all of the branches which are desirable to resect are easily accessible. The operation of nerve resection is based upon the principle that a muscle may be weakened to any desired extent by dividing all or part of its motor nerve supply, thus equalizing its strength with that of its antagonist and preventing spasmodic deformities. The operation, while technically somewhat difficult, is attended by very little surgical risk. The extent of nerve resection depends upon the spasticity of the muscles in each individual case. The nerves usually resected are in the leg, the branches of the obturator nerve supplying the abductor muscles of the thigh, the branches of the sciatic nerve to

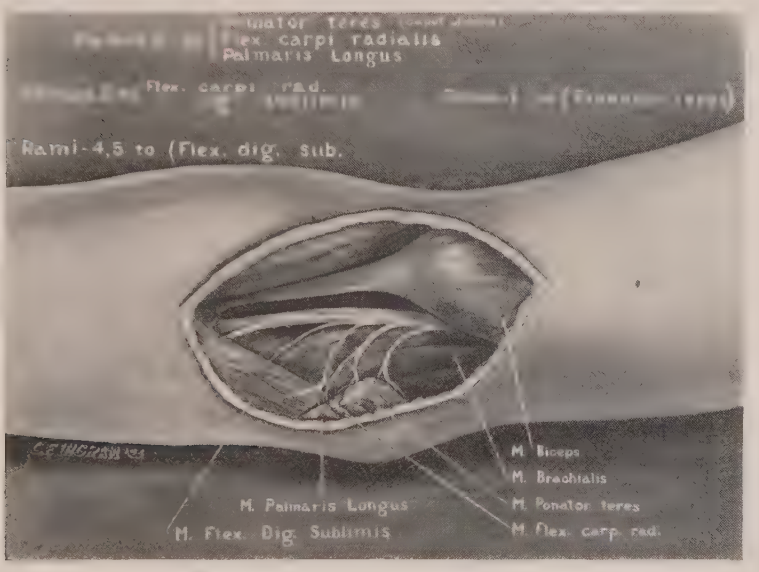


Fig. 445.—Branches of median nerve which are resected in Stoffel operation to relieve spastic contracture of hand.

the hamstring muscles and the branches of the tibial nerve to the calf muscles; in the arm, the branches of the median nerve to the pronator radii teres muscle and flexor muscles of the wrist and fingers. The ideal age for operation is about five years, though marked improvement may be secured even in adults. Myotomies and tenotomies on the overactive or contracted structures alone are followed by a high percentage of recurrence, because the excessive nervous stimuli are not controlled. However, fixed deformities must be corrected by orthopedic appliances or reconstruction operations on the bones and soft structures in addition to the operative measures to lessen the spasticity of the muscles.

Muscle training is an essential part of the treatment after all operative procedures and careful supervision of this feature will often determine the results obtained by operation. Massage and baking followed by a gradual cultivation of purposeful movements should be the aim. It is often six months or a year before the final results of treatment are obtained; this is particularly true in the hand where the motions are so much more delicate and complicated than in the lower extremity. Electrical stimulation and vibration are contra-indicated as the muscles are already in a state of hyperexcitability.

The Lower Extremity.—The Stoffel operation as applied to the lower extremity exposes the obturator nerve by the extrapelvic route where the terminal branches are reached through an incision on the inside of the thigh just below the pubic spine. The intermuscular septum between the adductor longus and adductor brevis is found and these two muscles separated. The anterior division of the obturator nerve will be found lying in the fascia on the upper surface of the adductor brevis. The posterior division lies between the adductor brevis and the adductor magnus; to reach it the adductor brevis is retracted upward and the nerve will be found lying in the fascia between it and the adductor magnus. In the severe cases all of the obturator nerve is resected, in the moderate cases about two-thirds or three-fourths of the terminal branches. The branches of the sciatic nerve are reached through an incision on the posterior surface of the thigh beginning just below the gluteal fold and extending downward for about 4 inches. The long head of the biceps femoris muscle may be retracted either to the medial or lateral side. On the median side of the sciatic nerve a large branch is given off which divides into three portions, one each to the semimembranosus, semitendinosus, and the long head of the biceps muscle. In the severe cases it is advisable to resect the entire supply to the long head of the biceps and the semimembranosus and about two-thirds of the supply to the semitendinosus. In the milder cases, especially where there is a tendency to internal rotation of the knee, the entire supply to the internal group is resected leaving the biceps intact, which helps to control the troublesome internal rotation.

The posterior calf muscles whose overactivity it is desirable to balance, are the gastrocnemius, soleus, and occasionally the tibialis posticus. An incision about 3 inches long is made over the popliteal space, and the tibial nerve which lies superficially to the vessels is exposed. The first nerve branch, a purely sensory one, is not disturbed. The next two branches, one on the inner and one on the outer side of the main trunk, are the branches to the inner and outer heads of the

gastrocnemius muscle; they are easily located and identified, and are completely resected. In severer cases, the branch to the soleus muscle is exposed between the two heads of the gastrocnemius muscle and about two-thirds of this branch resected. In the very severe cases the entire branch is sectioned. This still leaves some action in the soleus muscle as it is supplied by another small branch. The nerve to the tibialis posticus muscle can be reached, either by a somewhat more extensive dissection down the nerve, or by identifying the branch in the substance of the nerve trunk higher up, after the manner of Stoffel.

The Upper Extremity.—The median nerve furnishes branches to the pronator radii teres and the major portion of the flexor muscles of the wrist and fingers. The nerve is exposed through an incision over the bend of the elbow, as it lies between the biceps tendon and the pronator radii teres muscle. The first branch to the pronator radii teres is given off just above the muscle. The second branch supplies the flexor carpi radialis and the palmaris longus. The third branch supplies the flexor carpi radialis and the flexor digitorum sublimis, and is often fused with the fourth branch which supplies the flexor digitorum sublimis. Another large branch, the fifth, is distributed entirely to the flexor digitorum sublimis. The number and amount of each nerve resected depend upon the degree of the spasticity. If the wrist draws down to a right angle with each voluntary effort, a one-inch section through the entire first and second branches may be removed, as there are undoubtedly supplementary fibers to the muscles from other branches. In the severe cases, the third and fourth branches are resected also, if the presence of the fifth branch has been previously demonstrated. The ulnar nerve is exposed in its groove on the internal epicondyle of the humerus and traced downward along the edge of the flexor carpi ulnaris. Two small branches enter the muscles; these may be completely resected. The thumb is frequently drawn across the palm of the hand which prevents closure of the fingers or grasping of objects with the hand. The adductor muscles of the thumb are supplied by the terminal fibers of the deep branch of the ulnar nerve. An incision is made over the ulnar side of the palm. Both superficial and deep branches of the ulnar nerve are easily identified, and the deep branch is traced downward as it dips between the flexor and adductor of the fifth finger. The fibers of the opponens digiti quinti are separated and the nerve traced across the palm, the dissection being confined to the upper and palmar side of the nerve, leaving the distal or lower side from which the branches to the intrinsic muscles arise as little disturbed as possible. The deep branch is ex-

plored in this manner beyond the midline of the palm where the nerve divides and the terminal branches are resected.

OBSTETRICAL PARALYSIS

Injury to the brachial plexus at birth is often followed by a flaccid paralysis of the arm. The condition is known as obstetrical paralysis and results in a characteristic deformity of the extremity. The muscles of the upper arm alone may be affected or the paralysis may involve the entire arm and hand.

Etiology.—The nerve lesion is usually produced by tension on the brachial plexus in the course of a difficult labor. It may occur, however, during normal labor. Traction upon the head in head presentation, especially if the shoulder is depressed and the head bent toward the opposite side, stretches the upper nerve roots of the plexus. Should the stretching force continue, hemorrhage occurs or the nerves are torn. Rarely, in breech presentations, when the arm is carried above the head and traction made on the trunk, the tear occurs in the reverse direction, from below upward. If the upper cords of the plexus are torn, the muscles of the shoulder are paralyzed; if the lower cords are injured, the hand may be paralyzed, while the muscles of the upper arm are normal.

Fig. 446.—Obstetrical paralysis, upper arm type, showing limited abduction and external rotation of arm.

Pathology.—The paralysis may result from overstretching of the nerves without rupture. When this occurs, the paralysis is usually not permanent. The perineurium may be torn with hemorrhage into the perineural sheath, or the nerve may be frayed out like a rope which has parted under excessive tension. The tear practically always occurs from above downward; the fifth and sixth cervical nerves are most frequently injured. The suprascapular nerve is almost universally traumatized. This accounts for the prevalence of the upper arm type of paralysis. If the rupture involves also the seventh and eighth cervical and the first dorsal nerves, the entire arm is paralyzed. The tear may occur in the nerve

roots near the spinal cord, in the trunks of the plexus, or below the plexus. The nerves are replaced by scar tissue. In the older cases, the tip of the acromion process of the scapula is curved downward and forward, limiting abduction and external rotation of the arm, and the head of the humerus may be subluxated posteriorly.

Symptoms.—The symptoms depend upon the location and extent of the nerve lesion. In the upper arm type immediately following birth, the arm lies close to the side and is inwardly rotated. The abductor muscles and the external rotators are paralyzed. Later in untreated cases, the typical deformity results from unopposed contraction of the subscapularis, the latissimus dorsi, and the teres major muscles at the shoulders, and the pronators of the forearm. The arm is held to the side and can not be abducted. The elbow is extended, the forearm pronated, and the whole arm rotated inward. The child can not put his hand to his mouth without raising the elbow, nor put his hand on his head or behind his back. In paralysis of the whole arm type, the hand is also affected. In association with paralysis of the hand, an inequality of the pupils is often present. The pupil of the affected side is smaller and the palpebral fissure is narrowed. The eye symptoms are caused by injury to the sympathetic nerves and are of value in prognosis, as they are seen only in the more severe cases. Sensory changes, of course, can not be determined in the infant. In older children, sensation is rarely impaired. There is moderate atrophy of the arm, but not more than would be commensurate with disuse. The roentgenogram shows lack of development of the bones of the arm and shoulder. The scapula is elevated and the head of the humerus may be subluxated backward. The acromion process is bent downward more than normal, and after years have elapsed becomes elongated and interferes mechanically with abduction of the shoulder.

Diagnosis.—If the paralysis is noticed immediately after birth, the diagnosis should be obvious; later, the differentiation may be more difficult. Anterior poliomyelitis may closely resemble obstetrical paralysis, but the history of an acute onset in a previously healthy child and the association of paralysis elsewhere in the body are usually sufficient to differentiate the two conditions. In poliomyelitis the arm hangs loosely at the side without internal rotation, and the muscular atrophy may be extreme, especially in the deltoid muscle. The shoulder may be dislocated, but can be easily reduced. In spastic paralysis the tone of the muscles is increased and the reflexes are hyperactive. In birth fractures, the fracture is visible in the roentgenogram, and callus may be palpated after a few days.

Prognosis.—Like the symptoms the prognosis depends upon the extent of the nerve injury. If the paralysis has been caused simply by overstretching, the prognosis is favorable and becomes unfavorable in proportion to the extent of the initial lesion. The degree of the injury, however, can not always be determined immediately after birth. The prognosis is better in the upper arm type than in the lower arm type. The inequality of the pupils is an especially unfavorable sign. When treatment is instituted early, the prognosis is better than after contractures have been allowed to develop.

Treatment.—The treatment of obstetrical paralysis in the newborn consists of rest of the part for three or four months with the limb in the most favorable position to prevent contractures of the muscles and ligaments. This position is abduction to 90 degrees with full outward rotation and extension, and is maintained by a simple splint to the body and arm. Massage and passive stretching of the paralyzed muscles are of value. As soon as the child is old enough, active exercises should be carried out. Exploratory operations on the plexus are best deferred until the child is about one year of age. Little benefit can be expected from the operation, which, as a rule, is indicated only in the severe whole arm type. In older children in whom contraction of the arm has occurred, operations to correct the deformity are indicated.

Sever has devised an operation to relieve the adduction and inward rotation of the arm by dividing the tendons of the pectoralis major and subscapularis muscles.

Sever Technic.—An incision is made on the anterior aspect of the arm, beginning at the tip of the acromion process and carried down to below the insertion of the pectoralis major muscle. The cephalic vein is found generally in the outer edge of the wound and is tied or drawn aside. The tendinous insertion of the pectoralis major is defined, raised on an instrument, and divided all the way across. The pectoralis major muscle is then retracted inward out of the way, giving one a clear view of the axilla and shoulder joint. The arm should now be abducted fully and rotated outward as far as possible. With the arm fully abducted and outwardly rotated, the insertion of the tendon of the coracobrachialis muscle is defined. The origin of the coracobrachialis is separated from the coracoid process by means of an osteotome. This allows the muscle to slide downward out of the way and gives a much clearer field for exposure of the insertion of the subscapularis muscle. The tendon of the subscapularis should always be found, identified and lifted up before it is divided. Following the division of the subscapularis, outward rotation is perfectly free, as well as abduction. If at this stage there is still

some subluxation of the head of the humerus which cannot be fully reduced, an osteotomy of the acromion process should be performed, and the loose distal piece either removed or tilted up so as to allow the head of the humerus to slip back into the glenoid cavity. The wound is then closed with a few deep stitches and a continuous catgut suture for the skin. The arm is then placed on a wire splint which holds it elevated to or above the shoulder level, abducted, and fully rotated outwardly with the hand in full supination. At the end of ten days, massage, baking and exercises are begun, and are continued daily, or at least four times a week. The splint should be worn at night for at least three months, and in daytime for at least three months longer.

SPINA BIFIDA

Spina bifida is a condition in which the development of the portion of the vertebrae enclosing the spinal cord is arrested. Spina bifida

Fig. 447.—Spina bifida of fifth lumbar vertebra.

occulta consists of a defect of the vertebral arches without protrusion of the spinal cord or its membranes. A protrusion of the dura mater and

arachnoid is known as a meningocele. When the posterior wall of the involved vertebrae is entirely absent, exposing the medullary groove, the condition is called a myelocele. When the sac consists of dura mater and thin epithelium enclosing the spinal cord, nerves and cerebrospinal fluid, it is called a meningomyelocele. While the skeletal defect is ordinarily in the arches of the vertebrae the tumor protruding posteriorly, in rare instances, the vertebral bodies are defective and the hernia protrudes anteriorly into the abdomen, pelvis or thorax. Hydrocephalus

Fig. 448.—Clubfoot deformity resulting from spina bifida. The right leg was amputated for trophic ulceration.

Fig. 449.—Same as Fig. 448, after correction of deformity of right foot and fitting of artificial leg on left side.

is often associated with spina bifida and it has been suggested that increased cerebrospinal pressure has a direct bearing on the anomaly.

Symptoms.—The symptoms are largely referable to the nervous system. Symptoms of spina bifida occulta may not be apparent until adult age, and the condition is frequently revealed by roentgenological examination in individuals who are otherwise normal. The skin overlying the lesion may show hypertrichosis, pigmentation, and telangiectasis. There may be a dimple over the sacrum or lumbar region, and at times

the bony defect may be palpable. Diminished sensation, atrophy of the extremities, and trophic disturbances are of frequent occurrence, as well as paralysis of the vesical and rectal sphincters causing incontinence. Malformations of other parts of the body, such as congenital dislocations of the hip, syndactylism, clubfoot, and scoliosis, are frequently present. In meningomyelocele the anatomical defect is obvious at birth; the nutrition and physical resistance of the child are lowered and there are serious disturbances in the motor, sensory, and trophic functions of the nerves. The hernia is invariably situated in the median line, usually in the lumbar or sacral regions. It is round or oval in contour, soft in consistency, fluctuating and is sometimes reducible. The pedicle may be large or constricted and the tension within the sac varies with respiration, being influenced by crying, coughing, and sneezing. The sac wall frequently becomes necrotic, sloughs, and ruptures with the escape of spinal fluid. This allows infection to develop and death often ensues from meningitis or myelitis.

Diagnosis.—The diagnosis is comparatively simple, except in the occult variety. A tumor mass situated over the spine in the midline is almost always due to spina bifida. When nerve symptoms and deformity of the extremities are associated there can rarely be any question as to the diagnosis which may be confirmed by the roentgenogram. Differentiation from new growths, such as lipomas, dermoid cysts and teratomas, presents the only real difficulty. The consistency of such tumors is usually greater than that of the hernial sac in spina bifida and the roentgenogram of the spine is negative.

Treatment.—The indications for treatment vary with the severity of the symptoms. In spina bifida occulta no treatment for the defect itself is necessary, although correction of associated deformities may be required. At the other extreme are those cases with irreparable deformity, hydrocephalus, and complete paralysis of the sphincters and extremities. Palliative treatment consisting of protection and compression of the sac is all that can be accomplished when the neuroanatomical defect can not be influenced by any operation designed merely to correct the skeletal defect. In a selected group of cases, the hernial protrusion may be reduced, the nerve roots returned to the spinal canal, and the defect repaired by plastic procedures.

PROGRESSIVE CENTRAL MUSCULAR ATROPHY

Progressive central muscular atrophy is a chronic disease characterized by wasting of the voluntary muscles. It occurs usually in adults and, though beginning unilaterally, generally becomes bilateral. The

muscles of the upper extremity are involved more frequently than those of the lower. In the Charcot-Marie-Tooth type, the paralysis begins in the muscles of the legs and causes equinus or equinovarus deformity of the feet.

Etiology.—The atrophy and wasting of the muscles are associated with and result from a central nerve lesion. The cause of the disease is unknown, and it must still be classed in that group of neurological degeneration in which the primary cause is undetermined. Hereditary influences apparently have little to do with the condition, although several cases have been reported in the same family.

Pathology.—The pathologic process consists of a gradual degeneration of the motor ganglion cells in the anterior horns of the spinal cord and in the cortex of the brain. The neurons composing the motor tracts, particularly the pyramidal tracts, atrophy and are replaced by gliosis. In the muscles there is the typical atrophy and degeneration which accompanies any loss of motor nerve supply.

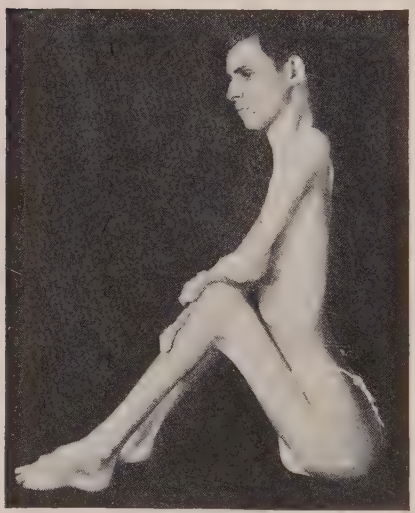


Fig. 450.—Extreme wasting in progressive muscular atrophy.

Symptoms and Clinical Course.—Contrasted with gross lesions of the pyramidal tracts when there is immediate complete paralysis of all the muscles below the lesions, progressive muscular atrophy develops insidiously, involving first one group of muscles and then another. It most often begins in the small muscles of the hand, the muscles of the ball of the thumb, the interossei and lumbricales being first involved. Hollow depressions between the metacarpals are characteristic of the early stage of the disease. Rheumatoid pains and muscular twitching may precede the atrophy. Fibrillary twitching of the muscle is a common symptom. Sensation is not impaired. The muscular weakness is slight at first, but becomes extreme in the later stages, being in ratio to the atrophy. When the upper motor neurons are chiefly involved, there may be spasticity of the affected muscles. The muscles of the forearm, shoulder, and trunk may next be effected; the lower extremities and face are attacked late. In the severer forms, the atrophy progresses until practically all the muscles of the body have disappeared

and the patient is truly nothing but skin and bones. The living skeletons seen in side-shows are usually victims of this disease. The patient gradually becomes bedridden, various deformities and contractures develop, depending upon which groups of muscles are most involved. Remissions may occur in which the patient will go for years without further progress of the disease, and a few cases have been reported in which the process was apparently permanently arrested.

Diagnosis.—Progressive muscular atrophy is a disease of adult life, usually coming on after the thirtieth year, and occurs very rarely in children. It is characterized by a gradual muscular wasting, usually beginning in the hands and extending to the rest of the body. There is no sensory disturbance and the reflexes are increased. The differential diagnosis must be made from muscular dystrophy, acute anterior poliomyelitis, syringomyelia, and the various forms of neuritis. In the muscular dystrophies the onset is usually during childhood. Hypertrophy of the muscles, so common in the dystrophies, is never present in progressive muscular atrophy. Heredity is a marked factor in the dystrophies, and no signs of nerve degeneration can be found. In the terminal stages, the appearance of the two conditions may be much the same, but a careful history should easily differentiate them. In anterior poliomyelitis, there is a history of an acute illness with sudden onset of the paralysis. The reflexes are abolished and the muscles have lost their excitability. This is exactly the reverse of progressive muscular atrophy. The sensory changes in syringomyelia, when present, easily distinguish it, but when absent, the two conditions are very similar. Peripheral neuritis usually involves one side of the body or the muscles supplied by the same nerve on the two sides, such as wrist drop in lead poisoning. Pain is also a more constant symptom in neuritis.

Treatment.—In the majority of cases, no treatment is of permanent value and the disease usually progresses to a fatal termination. Mercury and iodids, or arsenic, in the form of Fowler's solution, may be tried. If deformities are prevented by daily massage and proper splinting, the patient's ability to walk and to use the hands may be prolonged. Splints may be worn only at night, allowing free use of the extremities during the day. If deformity has already occurred, the advisability of correction by operative or mechanical means should depend upon the rapidity of the process and the extent to which it has progressed. If the disease is arrested or progressing very slowly, any reasonable procedure is justifiable to prolong usefulness.

MUSCULAR DYSTROPHY

Muscular dystrophy is a progressive disease characterized by muscular weakness and wasting, with or without a preceding hypertrophy. The condition is caused by degenerative changes in the muscles themselves and is not secondary to known neurological lesions. Pseudohypertrophic muscular paralysis is frequently discussed as a clinical entity, but in reality is a phase of muscular dystrophy. For convenience of clinical description, Erb has divided the cases into two groups: (1) Those which occur in childhood; (2) those which occur in youth and early adult life. The first group is further subdivided into (*a*) hypertrophic type, with pseudohypertrophy, and with real hypertrophy; (*b*) atrophic type, with involvement of the face, and without involvement of the face. The second group includes those cases occurring in young adults and the rare cases beginning after the age of twenty-five.

Fig. 451.—Muscular dystrophy with pseudohypertrophy of muscles and characteristic sliding through shoulders.

Etiology.—No definite cause has been found. Males are more often affected than females and heredity is an important element. The disease may occur in several generations in succession or in several members of the same family. The age of onset varies from two to sixty years, although most cases begin in early childhood.

Pathology.—There is an initial hypertrophy of the individual muscle fibers, soon followed by degenerative changes; the nuclei disappear and deposits of fat and fibrous tissue gradually replace the muscle fibers. During the first stage the muscles appear larger than normal, but are weaker than normal muscles of similar size. Hypertrophic and degenerative changes are often found at the same time in different fibers of the same muscle. The fat and fibrous tissues atrophy and the muscles waste to below normal size. In some instances the atrophy is primary, there being no initial stage of hypertrophy.

Symptoms and Clinical Course.—The symptoms usually appear in childhood, before the age of puberty. Clumsiness in walking, accompanied by an enlargement of the calf muscles, is first noticed. A careful examination will often reveal hypertrophy of the thigh and gluteal

muscles, and of the deltoid and triceps about the shoulder. The muscular weakness is often in marked contrast to the powerful appearance of the muscles. There are no sensory changes, and the neurological examination shows no abnormality. Sooner or later the characteristic atrophy takes place. The wasting of the latissimus dorsi and pectoral muscles cause one of Erb's diagnostic signs; when the child is lifted with the hands under the arms, the shoulders are raised to the level of the ears and the patient appears to be sliding through the shoulders. In standing, the legs are separated, the shoulders thrown back, the spine curved forward and the abdomen protruded. The gait is waddling and awkward. On attempting to rise from a sitting posture on the floor, the patient will "climb up his legs," first putting the hands on the feet, then on the knees, thighs and pelvis, and thus raise the trunk. The clinical course is usually slow, but steadily progressive; the wasting of one group of muscles follows another. The previously enlarged muscle groups gradually shrink until they are completely atrophied and the patient becomes so weak he can not stand or sit alone. Talipes equinus and flexion of the knees and hip may occur from muscular contraction. Lateral curvature, and at times a permanent flexion of the spine, may develop from weakness of the erector spinae muscles.

Diagnosis.—In typical cases the diagnosis is evident. A history of the disease beginning in childhood, with similar cases in the same or previous generations, can often be obtained. The enlarged muscles of the calves, thighs and shoulders, whose weakness is in marked contrast to their overdevelopment are characteristic in the early stages and produce the loose shoulders and the awkward waddling gait. During the later stages of the disease, when all the muscles are atrophied, or in the atypical cases, when atrophy of certain groups is the primary symptom, the diagnosis is often very difficult. In fact, it is believed that the muscular dystrophies, the progressive central muscular atrophies and the progressive neural muscular atrophies may be closely related. Muscular atrophy, due to cerebral lesions, is preceded by paralysis and there is no hypertrophic stage. In atrophy, due to peripheral neuritis, the distribution usually corresponds to that of one or more peripheral nerves; in multiple neuritis, the paralysis is out of proportion to the atrophy and the history of onset is different. In progressive central muscular atrophy, the disease usually begins in the small muscles of the hands, which are rarely, if ever, affected in the dystrophies. The central atrophies appear late in life and show little hereditary influence. Neurological changes, such as increased reflexes, spasticity, and fibrillary twitchings in the muscles, are absent in the dystrophies.

Prognosis.—The prognosis is usually unfavorable, although, in some cases, the progress is remarkably slow, but the final outcome is invariably total disability. Periods of remission may occur and the patient go well into adult life before the muscular weakness seriously affects his activities.

Treatment has no effect on the outcome of the disease. The progress may be delayed and the function of the muscles prolonged by massage and electrical stimulation. Contractures, particularly of the Achilles tendon and the knee flexors, which occur late in the disease, may be prevented by splints which hold the feet at right angle and the knees extended. When the disease is arrested, surgical measures for correction of deformity and stabilization of joints may be indicated in rare cases.

HEREDITARY ATAXIA
(Friedreich's Ataxia)

Hereditary ataxia is a peculiar tabetic affection of distinctly hereditary or familial occurrence. Several children in the same family are usually affected. The onset is in childhood, about 90 per cent occurring before the fifteenth year and most of them before the tenth. The disease is caused by an extensive sclerosis or degeneration of the nerve fibers in both the dorsal and lateral tracts of the spinal cord.

Symptoms.—The incoordination resembles that of locomotor ataxia, but the gait is swaying and irregular, like that of a drunken man, and there is not the characteristic "stamping" of a true tabes. The feet are placed widely apart in walking, from a sense of weakness and insecurity. Ataxia of the arms and hands is an early symptom and the athetoid movements are much like those in chorea. The hand will sway over an object for a moment and then pounce upon it. Choreiform movements of the face and head occur. Nystagmus, with constant twitching of the eyes from side to side, is a constant and characteristic symptom. Disturbance of speech is also common, the patient talking as if he had a foreign body in his mouth. The expression of the face is dull, although the mentality is usually good. Deformities of the feet frequently develop, usually an equinovarus or clubfoot type, and lateral curvature of the spine may be present. Sensory disturbances are variable. The deep reflexes are abolished early, this being one of the most constant and characteristic symptoms, and one which helps to differentiate this disease from chorea or spastic paralysis. The pupillary reflex to light is practically never affected; the absence of the Argyll Robertson pupil helps to distinguish hereditary ataxia from tabes dorsalis.

Diagnosis and Treatment.—The diagnostic points make the disease unmistakable and are practically always present: (1) Ataxia, involving the arms and legs, beginning in childhood, and often affecting several members of the same family; (2) nystagmus; (3) slow, scanning speech; and (4) loss of the deep tendon reflexes and retention of the pupillary reflex to light. The affection is incurable. Deformities, such as equinovarus of the feet, can be corrected as they occur and their recurrence prevented by the use of braces, as in the treatment of clubfoot. Stabilization operations may be performed in selected cases after progress of the disease is arrested.

INJURIES TO THE PERIPHERAL NERVES

Injuries to the peripheral nerves may complicate fractures, lacerating wounds, or other forms of trauma. Certain nerves are subcutaneous or lie in close proximity to the adjacent bony part; usually there is enough mobility of the nerve to allow it to slide and so escape injury. In locations where the nerves are bound firmly to the bone, as the radial nerve in the musculospiral groove of the humerus, the ulnar nerve over the internal condyle of the humerus, and the anterior peroneal around the upper end of the fibula, injury is of frequent occurrence. In fractures, when the nerve escapes injury at the time of the initial injury, it may later become compressed by the formation of callus or scar tissue, producing a painful neuritis, termed "causalgia." Partial or complete paralysis below the lesion may result. Any of the peripheral nerves may be severed by cuts, lacerations, or gunshot wounds of the soft tissues. The common site is the peripheral nerve trunk, although the brachial or lumbar plexus may occasionally be injured. The severance may be partial or complete. Excessive swelling or constriction of an extremity, occurring after the application of a splint or cast, may cause paralysis by pressure. Stretching of the nerve by extreme tension upon the extremity may rupture the fibers. Obstetrical paralysis by traction on the arm during childhood, catching of the arm in a revolving belt or wheel, or the weight of a heavy object falling across the shoulder, are examples of such injuries. Toxic or inflammatory neuritis (seen in lead poisoning), diphtheria, etc., may cause paralysis and rarely benign or malignant tumors may involve the nerves, either primarily or secondarily, by infiltration.

Pathology.—The pathology varies with the type and degree of the injury. Following a contusion, the perineural sheath may become distended by edema and a hematoma may form within the sheath; later the nerve fibers are compressed by the formation of scar tissue. In

fractures, adjacent nerve trunks are often surrounded by a mass of callus which constricts the nerve. After complete or partial severance the ruptured nerve fibers separate; the distal segment loses its function and undergoes degeneration. The injury produces an effusion of blood, and migration of leukocytes takes place into and about the end of the proximal segment and throughout the entire distal segment. The axis-cylinders perish, the myelin sheath is absorbed and the cells along the inner surface of the neurilemma cease to proliferate. The sheath shrinks and becomes empty except for scattered masses of nuclei and protoplasm. The degeneration occurs rapidly beginning within twenty-four hours after the injury and is complete in a few days. The leukocytes are replaced by connective tissue cells which absorb the fatty myelin and the axis-cylinders, and the degenerated nerve trunk becomes hard, fibrous, and cirrhosed. In the proximal end of the divided nerve, an end-bulb is formed by curling up of the prolonged nerve fibers and fibrous tissue. While degneration occurs in a few days, regeneration requires months. The exact method of regeneration is uncertain. Partial regeneration undoubtedly occurs in the distal segment, independently of the proximal, although complete regeneration is not possible unless the two segments are in apposition. The generally accepted theory is that the nerve is regenerated by the prolongation of the existing nerve fibrils in the proximal segment. The fiber which is at first composed of myelin pierces the granulation tissue between the nerve ends and enters into the empty sheath of the distal segment. It grows slowly along the scaffold of the degenerated trunk and function is reestablished only when the new axis-cylinders have permeated the nerve.

Symptoms and Diagnosis.—The symptoms upon which the diagnosis of nerve injury may be made are paralysis of the muscles supplied by the nerve below the lesion and loss of cutaneous sensation. Sensory function consists of a number of different objective and subjective sensibilities, any one or all of which may be lost, depending upon the location and completeness of the injury. The subjective sensation is how the part feels to the patient, including pain, numbness, and tingling. The important objective sensations are touch, pain, temperature, and joint sense. Touch is best determined by passing a bit of cotton or soft cloth over the skin. Hard pressure will give deep joint and muscle sensations and confuse the picture. Pain is tested by pricking with a sharp pointed instrument, and comparing the intensity with the opposite side. The discrimination between sharp and dull stimuli is also important. Temperature sense is the ability to distinguish the difference between hot and cold; small glass tubes of hot and cold water are a convenient means

of making this test. Joint sense is examined by passively moving the joint while the patient has his eyes closed. When any part of the extremity is moved the patient should be able to appreciate the new position. This is a deep sensation in tendons and muscles, and is usually retained, unless all the peripheral nerves are involved or the lesion is in the spinal cord. When the nerve supply is lost, there is a disturbance of the circulation and nutrition of the affected part and trophic changes occur. This is evidenced by a slight cyanosis and coldness, by excessive perspiration, and a glossy and tight appearance of the skin. Small blisters frequently form which may exfoliate, leaving ulcers which are difficult to heal. The muscles undergo atrophy, contracture of the tendons develops, the bones become atrophic, and the joints become stiffened. In the hand this results in the typical clawhand, with the metacarpophangeal joints hyperextended, the fingers flexed, and the thumb drawn against the palm.

As a general rule, the symptoms are so definite that no difficulty is experienced in determining their presence. However, the nerve injury may be unnoticed when the attention is centered completely on the associated conditions. The observance of a few simple rules when the patient is first examined may save much embarrassment later: (1) In all fractures of the humerus involving the middle and lower thirds, or in lacerated wounds over this area, active motion of the wrist and fingers should be carefully determined. Inability to dorsiflex the wrist means an injury to the musculospiral nerve. (2) In extensive fractures about the elbow, particularly those around the internal condyle, the sensation of the little and ring fingers should be tested. Numbness in this region indicates an injury to the ulnar nerve. (3) In all cuts across the flexor surface of the wrist, the sensation over both the ulnar and radial sides of the hand and fingers should be noted. Roughly, the median nerve supplies sensation to the radial or thumb side, and the ulnar nerve to the opposite side of the hand. All of the small muscles of the hand are supplied by these two nerves through branches which are given off below the wrist. If the patient can fully separate and approximate the fingers and can accurately touch the tips of the four fingers to the thumb, there is, in all probability, no motor nerve injury. (4) In fractures of the upper end of the tibia and fibula, particularly when associated with crushing or twisting of the knee, the patient should be requested to dorsiflex his foot. If this is impossible, the muscles on the anterior and outer side of the leg supplied by the common peroneal nerve are paralyzed. (5) Electrical stimulation of the muscles is often necessary in determining whether the lesion is partial or complete.

Treatment.—Simple contusions, hematomas, partial severance, and the toxic or inflammatory types of neuritis should be treated conservatively. Many nerve lesions are only temporary and function returns spontaneously. It is often difficult or impossible to tell whether a nerve has been divided or simply bruised. For this reason, unless it is obvious that the nerve has been severed, conservative treatment should be given a thorough trial before operation is advised. If, at the end of three or four months, there is no return of sensation or muscle reaction, exploration should be advised. During the period of conservative treatment, proper splints should be employed to prevent overstretching of the paralyzed muscles by their active antagonists, or by the force of gravity. The hand should be in dorsiflexion on a cock-up splint, with the metacarpophalangeal joints flexed. The knee should be held constantly in extension and the foot at a right angle by splints or braces. Physiotherapy, in the form of massage, electrical stimulation of the paralyzed muscles, and active and passive motion, should be employed.

Surgical Treatment.—When a nerve is seen to be divided in a recent open wound, suture should be performed at once, even though infection is anticipated. Suture prevents retraction of the nerve ends and troublesome shortening, which make later operations so difficult. Primary union or healing, with only slight infection, may occur, and the nerve is then in the most favorable position for regeneration. After primary suture, or after three or four months of conservative treatment, if there is no return of motion or sensation, it is reasonable to assume that the nerve has either been completely divided or that so much scar tissue has formed that regeneration is not possible. Exploration should then be done and the nerve sutured, care being taken to remove all neuromas and scar tissue from the nerve ends. At least six months is required for restoration after suture. Many cases do not show definite return of motion for over a year, although there is often an improvement in the nutrition and sensation of the part before this time. Successful results in nerve sutures vary somewhat with the nerve involved, and the longer the period between injury and suture, the less favorable is the prognosis. Return of function is rarely observed in cases of complete nerve severance existing for two years. Physiotherapy should, of course, be combined with the operative treatment. When the symptoms of extreme pain or gradually increasing motor and sensory paralysis make it certain that a nerve is being compressed by scar tissue or callus, freeing of the nerve by open operation offers the only hope of relief. The nerve should be freed at the point of pressure and for several inches, both above and below, in order that it may be transplanted into a new bed of healthy

soft tissue. If the nerve has not been badly damaged, there is usually prompt relief of pain and early return of function. When scar tissue has invaded the nerve trunk, causalgia may persist indefinitely, and even exploration and the removal of scar tissue may have no beneficial effect upon the traumatic neuritis.

Tardy Ulnar Palsy

Delayed or tardy paralysis of the ulnar nerve may follow fractures of the elbow, especially fractures of the external condyle of the humerus. This injury occurs during childhood and is often improperly treated; cubitus valgus results with an increase in the carrying angle which gradually stretches the ulnar nerve in its groove on the internal condyle of the humerus.

Symptoms and Diagnosis.—The symptoms appear years after the injury, and consist of paralysis of the muscles of the forearm and hand, loss of sensation, atrophy of the hand, and contracture of the fingers. All of the muscles supplied by the ulnar nerve, *i. e.*, the flexor carpi ulnaris, the two inner heads of the flexor digitorum profundus, the interossei, dorsales volares, the ulnar lumbricales, the palmaris brevis, the abductor minimi digiti, the opponens digiti quinti, the adductor pollicis and the inner head of the flexor pollicis brevis, may be affected. Sensory changes appear late and may be very slight. The epicritic sensibility is disturbed more than the protopathic. In addition to the deformity at the elbow, the muscles of the forearm and the intrinsic muscles of the hand are atrophied. The ulnar and hypothenar eminences are smaller than normal; the spaces between the metacarpal bones are depressed; the movements of the fingers are delayed and the grip is weakened. The diagnosis is based upon the history of injury to the elbow, the demonstration of the fracture by the roentgenogram and the characteristic symptoms.

Fig. 452.—Old fracture of external condyle of humerus producing tardy ulnar palsy.

Treatment.—The prophylactic treatment is most important. Fractures of the humerus in young children should be restored to anatomical

position, or, if this is impossible, the cubitus valgus should be corrected by a supracondylar osteotomy. When the paralysis is well established, the treatment consists of transplantation of the nerve to the flexor surface of the elbow joint. Neurolysis and resection of neuromas, when present, with suture of the nerve may be necessary.

Irreparable Injury to the Radial Nerve

Injury to the musculospiral and posterior interosseous nerves is followed by paralysis of the extensor muscles of the wrist and fingers and loss of sensation over the area of radial nerve distribution. The lesion occurs in fractures of the shaft of the humerus and in gunshot or other lacerating wounds of the arm and forearm. Destruction of a large segment of the nerve trunk or wide separation of the nerve ends may make the injury irreparable by the ordinary methods of nerve suture.

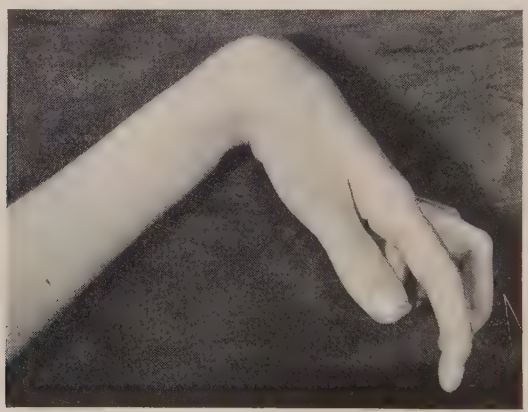


Fig. 453.—Wristdrop following severance of radial nerve.

Treatment.—Unless an end-to-end anastomosis can be secured, an operation for tendon transplantation is indicated. The technic usually employed is that devised by Jones. In injury of the musculospiral nerve above the level of the origin of the posterior interosseous branch, the flexor carpi radialis muscle may be inserted into the three extensors of the thumb and to the extensor of the index finger. The flexor carpi ulnaris is transplanted into the extensors of the remaining three fingers and the pronator radii teres is transplanted into the extensor carpi radialis longus and brevus. When the lesion is below the origin of the posterior interosseous nerve, the radial extensors of the wrist are intact and the transference of the pronator radii teres is, of course, unnecessary. Stiles has modified the original operation by inserting the tendon

of the palmaris longus into the extensor pollicis longus; the flexor carpi radialis into the extensor primi internodii pollicis and the extensor ossis metacarpi pollicis; and the flexor carpi ulnaris into each of the extensor digitorum tendons. The hand is immobilized for two weeks in dorsiflexion, the wrist being kept almost at right angle, and the metacarpophalangeal and interphalangeal joints being only slightly palmarflexed to avoid subsequent stiffness. The after-treatment consists of daily massage and electrical stimulation. Recovery is usually complete in from eight to ten weeks, and the position of extension must be maintained until there is return of voluntary function.

HYSTERICAL PARALYSIS

Hysterical paralysis usually occurs in girls about the age of puberty, following some emotional shock. The paralysis develops suddenly and may persist for variable periods of time, from a few hours to many weeks or months. The spine, the upper or lower extremities, may be affected. The symptoms are characteristic in that the distribution is without regard for anatomical structure. The paralysis may be spastic or flaccid in type, but differs from organic lesions in certain important details; a functional group of muscles is always involved, the posture of the part is abnormal, the reflexes are lost or abnormal reflexes may be present. Hysterical anesthesia is usually of the stocking or glove type of distribution. The diagnosis may be difficult, but by close observation, the physician will usually find some signs or symptoms which do not correspond to those of an actual organic lesion. The advance of the paralysis or anesthesia in response to suggestion by the physician is a valuable diagnostic point. The paralysis may disappear spontaneously, and the treatment is by suggestion. Once the confidence of the patient has been secured by the physician, any form of treatment will be successful.

BIBLIOGRAPHY

Förster, O.: Ueber eine neue operative Method der Behandlung spastischer Lamüngen mittels Resektion hinterer Ruckeumarks wurzeln, Ztschr. fr. Orthop. Chir., 22 : 203, 1908.

Jones, Sir Robert: Tendon Transplantation in Cases of Musculospiral Injuries Not Amenable to Suture, Amer. Jour. Orthop. Surg., 35 : 333, 1921.

Royle, N. D.: Treatment of Spastic Paralysis by Sympathetic Ramisection, Proc. Roy. Soc. Med. (Sect. Orthop.), 20 : 63, 1927.

Sever, J. W.: A Text-book of Orthopedic Surgery, New York, The Macmillan Co., 1925, p. 223.

Stiles, Sir Harold: Operative Treatment of Nerve Injuries, Amer. Jour. Orthop. Surg., 16 : 351, 1918.

Stoffel, Adolph: The Treatment of Spastic Contractures, Amer. Jour. Orthop. Surg, 10 : 611, 1912–1913.

CHAPTER XVII

STATIC DEFORMITIES

The weight of the body through gravity exerts a constant pressure downward which normally is distributed evenly throughout the entire spine and lower extremities; improper distribution of the body weight on its bony framework induces postural abnormalities which are known as static deformities. The bones of the spine and the lower extremities, being the only portions of the human skeleton concerned with weight bearing, are naturally the regions most affected. As a whole, the postural group comprises the largest class of deformities which require orthopedic treatment. Many static affections originate in childhood, but are not noticeable before adolescence, or may cause no symptoms until early adult life. However, if discovered early and properly treated, correction may often be obtained and much disability in later life prevented. The body weight of the young child is light and occupation plays an insignificant rôle. But, as the weight increases and occupations are assumed which require prolonged sitting or standing in faulty attitudes, any static deformity may become exaggerated. The affections which will be considered are flatfoot, hallux valgus, hallux varus, hallux rigidus, metatarsalgia, clawtoe, pigeon toe, march foot, scoliosis, round shoulder, hollow back and visceroptosis.

FLATFOOT

The term "flatfoot" is applied to the faulty pronated condition of the foot which impairs its weight-bearing function. Other terms, as "pes planus," "pes valgus," "foot strain," "weak foot," and "pronated foot," are, at times, employed to designate the affection, but flatfoot is the one most often used.

Anatomy and Physiology of the Foot.—The normal foot is roughly triangular in shape, the apex being posteriorly at the heel. The bony units, twenty-six in number, are arranged in three groups: the seven tarsal, the five metatarsal, and the fourteen phalanges. The relatively large number of bones allows greater mobility, but lessens the resistance of the support. Longitudinally, the bones of the foot may be divided into two sets: The medial, lying in relation to the tibia, transmits the body weight and is composed of the astragalus, the scaphoid, the three

cuneiform bones, and the medial three metatarsal bones with their phalanges. The external set is placed in relation to the fibula and consists of the os calcis, the cuboid bone, and the outer two metatarsal bones and their phalanges. The external set of bones is chiefly concerned with balance. It should also be noted that the great toe has only two phalanges instead of three, as have the other toes, which gives increased strength at the expense of mobility. The tarsal and metatarsal bones together are arranged to form two arches, a longitudinal and a transverse. The anteroposterior arch has its summit at the top of the astragalus where that bone articulates with the tibia. The hind limb of the arch is formed by the posterior half of the astragalus and the posterior half of the os calcis. The anterior limb is formed by the anterior portions of the astragalus and os calcis, the other tarsal bones and all the metatarsal bones. The inner division of the anterior pier of the longitudinal arch which consists of the astragalus, the scaphoid, the three cuneiform bones and the medial three metatarsal bones, is much more highly arched than the outer division, especially at its tarsal portion. The outer bears less weight and this is distributed directly through the astragalus to the os calcis. The medial pier is more apt to sink, because of its elevation, while the external pier is always in contact with the ground. Besides, the tarsal portion of the inner arch is less solid than that of the outer due to the greater number of bones involved. The arch is more elastic and it transmits the greater part of the weight of the body. The transverse arch is most marked in the region of the cuneiform bones. This arch provides elasticity to the foot and gives safe lodgment for vessels and nerves. Practically, it must be understood that when the foot is firmly resting on the ground, the weight of the body is borne upon the os calcis, the cuboid, the entire length of the fifth metatarsal bone and the heads of all the metatarsal bones. At the level of the metatarsal heads, a transverse arch is apparent in the relaxed foot but this cavity disappears when weight is borne.

The contour of the arches is formed by the shape of the bones, but their integrity is maintained by the fascias of the sole of the foot, the strong ligaments of the tarsus, and metatarsus, the decussation of the tendons of the tibialis posticus and peroneus longus muscles, the plantar group of muscles, the tibialis anticus muscle, and the internal lateral or deltoid ligament of the ankle joint. The plantar fascia forms a thick triangular band in the center of the sole, which is attached posteriorly to the tuberosity of the os calcis, and anteriorly by five separate slips to the sides of the metatarsophalangeal articulations and the bases of the proximal phalanges. The central portion of the plantar aponeurosis

assists in preserving the arch of the foot by drawing the toes and the calcaneus together. The inferior calcaneoscaphoid ligament passing from the sustentaculum tali and under surface of the os calcis to the whole width of the under surface of the scaphoid bone and to its medial surface behind the tubercle, blends with the internal ligament of the ankle joint and the external calcaneoscaphoid ligament. The thickest portion of the ligament is along the inner border of the sole, and this area is further strengthened by the tendon of the tibialis posticus muscle. The inferior calcaneoscaphoid ligament forms a hammock beneath the head of the astragalus and limits downward motion. Flatfoot may be said to be a direct consequence of stretching of the calcaneoscaphoid ligament, for the head of the astragalus is pressed forward and inward, and overextension, with rotation outward of the forepart of the foot results. The long and short inferior calcaneocuboid ligaments sustain chiefly the outer division of the arch, but also support the rest of the foot to some degree.

The muscles, whose action aids in preserving the arch, are the tibialis anticus, the tibialis posticus, the flexor digitorum longus, the flexor hallucis longus, and the peroneus longus, brevis and tertius. The tibialis anticus, peroneus brevis and tertius are inserted into the convexity of the arch and tend to pull it upward. The flexor longus hallucis, and flexor digitorum longus run longitudinally beneath the arch and support it directly. The tendons of the other two muscles cross in the sole of the foot, support it as in a sling, and spread out to insert into the plantar surfaces of the tarsal and metatarsal bones, the posterior tibial tendon particularly having a very extensive area of attachment to practically all of the metatarsal and tarsal bones with the exception of the astragalus. In walking, as the heel first makes contact with the ground, the foot is slightly adducted beneath the astragalus. As the body is swung forward to the vertical position, first the outer and then the inner toes touch the surface, while the head of the astragalus presses against the scaphoid and sinks downward upon the calcaneoscaphoid ligament, the foot meanwhile becomes slightly abducted beneath the astragalus. As the opposite foot is brought forward and the weight shifts inward on the heads of the metatarsal bones, the heel is raised; the final act in each step is a propulsive force given by the great toe.

Etiology.—According to Davis, the weight borne on the foot while standing is a static force, while that sustained in walking is a dynamic force. When the foot is firmly placed upon the ground, the weight of the body is transmitted in an oblique direction from above downward and inward; this being true, if the ligaments between the astragalus and

os calcis and the internal lateral ligament of the ankle joint did not check abduction, inward displacement of the astragalus from beneath the arch of leg bones would be prevented only by the tendons passing around the inner side of the ankle joint. In general, the deformity is caused by a disproportion between the weight to be borne and the muscular power which bears it. When a person subjected to prolonged standing strain is unable to support the weight by muscular contraction, the muscles relax, the weight is then borne on the ligaments, the arch descends and flatfoot results. As the muscles relax and the weight of the body is supported by the ligaments of the foot, the astragalus rotates downward and inward upon the os calcis; the os calcis is forced into the pronated position, and the scaphoid bone is depressed together with the head of the astragalus. The forepart of the foot is abducted and there is a bulging inward of the medial border of the foot. The foot is displaced outward on the leg, so that the line of weight bearing, prolonged through the crest of the tibia, instead of falling in line with the second toe as it normally does, now falls over the great toe or even internal to the medial border of the foot. The foot is also rotated outward on the bones of the leg. The normal range of movements of the foot is restricted. Plantarflexion is limited and likewise adduction and inversion.

There are many degrees of the condition beginning with the painful weak foot in which the symptoms are due to abnormal and prolonged strain on the ligaments. As the ligaments gradually stretch and the bony arch is depressed, contractions occur which ultimately prevent the resumption of the normal posture. The ligaments on the inner border of the foot become permanently stretched; a contraction of the tendo achillis and of the structures on the outer side of the foot occurs, so that adduction and inversion may be impossible. The peroneal muscles, in particular, become spastic. Infection of the focal type, in adults, is a frequent predisposing factor, and flatfoot is often associated with infectious arthritis. Hereditary weakness is one of the most important predisposing factors. The affection is frequently seen in successive generations and in several members of a single family and the severe cases of the deformity always begin in early childhood.

Symptoms.—Clinically, flatfoot may be divided into two groups: the flexible, weakened or strained foot, and the rigid flatfoot. In the advanced cases, the characteristic deformity previously described is apparent. In milder cases, the foot may appear normal when the patient is inactive, but the deformity will appear as soon as weight bearing is assumed. In still milder or early cases, the contour may be normal, even

when subjected to weight bearing. Pain is usually the first symptom and in adults is the cause of the patient's seeking medical aid. Children, as a rule, have less pain, probably because the body weight is less and the daily occupations not so exacting. Pain at the onset is limited to

Fig. 454.—Weak foot or flatfoot in child showing depression of longitudinal arch. Anteroposterior view.

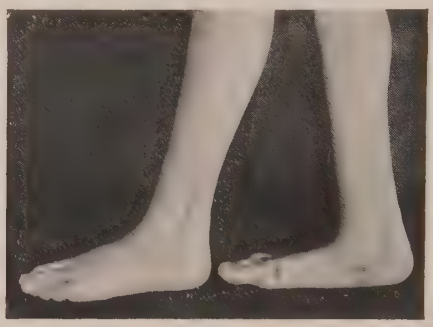


Fig. 455.—Same as Fig. 454. Lateral view.

the period of walking and standing, but as the condition advances, pain becomes more persistent and continuous. The locations of the pain are along the medial border of the foot at the intersection of the stretched

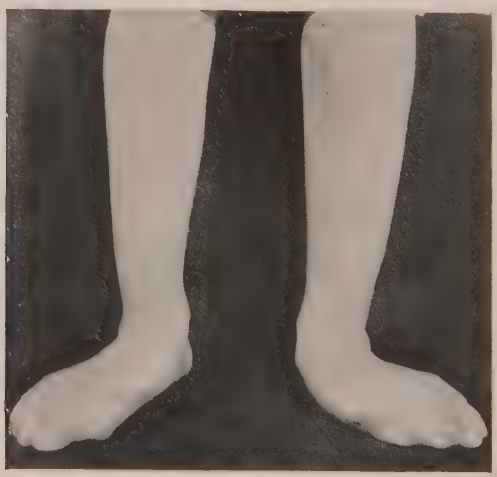


Fig. 456.—Spastic flatfoot in adult.

ligaments into the scaphoid and other tarsal bones, the anterior portion of the foot, beneath the os calcis at the origin of the plantar fascia and plantar ligaments, behind the medial malleolus, and at times along the outer border of the foot. Occasionally the poor posture also induces

pain in the calves of the legs, the knees, hips, and back. Tenderness is often present on the points of ligamentous strain and muscular spasm, especially spasm of the peroneal muscles is associated with the rigid type of flatfoot. Stiffness and loss of flexibility gradually develop and the absence of elasticity in the gait is noticeable.

Examination.—The examination consists of a careful inspection of the foot in walking and standing; the distribution of the weight, the general contour of the feet, and the condition of the arches should be noted. Active and passive movements in flexion, extension, abduction, adduction, eversion, and inversion are tested, and special note should be made of limitation of motion in adduction and inversion. Muscle power should be determined to differentiate the affection from a paralytic condition. Points of tenderness may be located about the astragaloscaphoid joint, the internal malleolus, under the os calcis, or in the sole of the foot. The examination of shoes that have been worn for some time is of value in demonstrating the tendency to run over the heels and counters to the inner side. The roentgenological examination is usually negative, but in advanced cases may demonstrate the flattening of the arch with the resulting change in the relations of the tarsal bones. The osseous changes on the inner aspect of the foot vary with the age of the patient and with the deformity. In cases of long standing, the head and neck of the astragalus have grown appreciably longer and the scaphoid is hypertrophied on its inner aspect. Arthritic changes may also be present when the condition is of long standing or associated with an infectious type of arthritis.

Diagnosis.—The diagnosis is made from the symptoms and physical findings. The deformity, stiffness, and rigidity are characteristic, but pain in the feet may be due to other causes than flatfoot, even though flatfoot is present. The condition must be carefully differentiated from infectious arthritis, acute traumatic arthritis, destructive processes in the tarsal bones, and arterial diseases, such as endarteritis obliterans and thrombo-angiitis.

Prognosis.—The prognosis, when the condition is recognized early and appropriate treatment instituted, is good. Children, as a rule, improve rapidly, but treatment must be continuous for several years if disability in later life is to be prevented. In the congenital type of flatfoot, the normal contour of the foot may never be secured, although the other symptoms may be relieved. In adults the outlook is less favorable and pain may persist almost indefinitely.

Treatment.—The treatment of weak feet may be divided into: (1) treatment by exercise and physiotherapy; (2) treatment by supports,

including proper shoes, and (3) operative treatment. A combination of all three methods may be necessary to restore the affected foot to normal. In every case, however, the restoration of function depends entirely upon muscular development, which can only be accomplished by continuous exercises of the feet, faithfully carried out over a long period of time.

Exercises and Physiotherapy.—Exercise may be taken with or without weight-bearing. In the severer types of pronated feet, exercises without weight-bearing should be prescribed first and exercises performed with weight-bearing gradually included. The exercises for the toes without weight-bearing are flexion and extension of the toes, for the foot, strong plantarflexion, adduction and inversion of the forefoot, and finally dorsiflexion. As ordinarily performed, the exercise of rising on the toes is of little value and may even be productive of harm in the case of very weak feet. If done at all, the patient should rise as high as possible on the toes, separating the ankles slightly while rising. Rising to the extreme degree calls into full use the muscles of the forefoot and deepens the arch by the bowstring action of the muscles; separating the ankles in rising affects the adductors of the foot and to a lesser degree the outward rotators of the hip. As this exercise, if properly done, requires a considerable degree of strength, it should not be used at first, and not at all in the case of very weak feet. The following list of exercises suggested in Medical War Manual No. 4, will suffice for all except special cases:

1. Rising on the outer borders of the feet; stand with the feet parallel and rise on the outer borders without twisting the legs or bending the knees. In this exercise the movement takes place entirely below the astragalus; it calls the adductors of the foot only into play.

2. Walking on the outer borders of the feet; with the feet parallel, rise on the outer borders and walk in this position. This has the same action as Exercise 1, provided the legs are not twisted outward; if one toes-in or twists the legs outward, the rotators of the hip are called into play.

3. Rotating the legs outward; stand with feet parallel, or slightly toed-in, and twist the legs outward from the hip, keeping the knees straight and the great toe in contact with the ground. This is a pure hip motion, the leg rotating outward at the hip and ankle with the foot remaining fixed; it calls into play the outward rotators of the hip; its action in correcting pronation and throwing the weight on the stronger outer portion of the foot is striking. This exercise frequently will be found difficult to learn by persons with weak feet.

4. The ball of the foot is placed on the sharp edge of a depression in the ground with the toes projecting over the edge. A thick board table or other secure support may be used. The toes are deliberately bent downward as far as possible. If the toes do not bend readily, assist them with the hands until they become more flexible.

5. The foot is moved backward to a flat surface and the toes are lifted.

6. In the same position the toes are separated and closed. At first it may be necessary to assist this movement with the hands.

The last three exercises develop the intrinsic muscles of the foot and raise the anterior arch. Practically all patients with weak feet need instruction in standing and walking properly. Exercises in corrective walking should be practiced with the foot adducted and its inner border elevated. In making each step, the weight should be borne on the heel and outer border of the sole. Walking along a double inclined plane may be of value by compelling the foot to assume the proper inverted position. Exercises should be carried out at home twice a day, but will not be persisted in unless the patient is under the direct supervision of the physician. Alternating hot and cold foot baths stimulate the circulation, and massage is of value in restoring tone to the weakened muscles.

Supports.—An efficient foot-strapping is one of the best methods of treatment and should be applied in all except the very mild cases. The strapping also acts in the nature of a therapeutic test; if the condition is purely a static one, proper strapping will usually give immediate relief of pain. If the strapping does not give relief, it is often found that there is some other cause, such as arthritis, and a careful search for possible foci of infection should be made. The technic of applying a foot-strapping is as follows: The foot and leg are shaved. The patient is instructed to hold the foot at a right angle with the leg and strongly inverted. It may be necessary to have the foot supported in this position by an assistant, or the patient may help maintain it by a sling of bandage about the forepart of the foot. Zinc oxide adhesive plaster is used in 2-inch width strips. The first strip begins just above the lateral malleolus, passes under the heel and up the inside of the leg as high as to the level of the tibial tubercle. The plaster is pulled tightly and held until it adheres to the skin. The first strip may be reenforced by another strip placed slightly anterior to and overlapping it. The next strip begins at the outer side of the foot, passes under the arch, up over the astragaloscaphoid joint, across the dorsum of the ankle to the outer side of the leg, and spirals about the leg one complete turn, ending at the level of

the tibial tubercle. A few circular strips are then placed about the leg to hold the long strips in place. This strapping may be left on for four or five days and should be renewed as often as necessary until all pain has disappeared. When the pain has been relieved, it becomes necessary to prescribe some form of permanent support. In mild cases, arch supports are applied without preliminary strapping; when pain is severe, the symptoms are first relieved by strapping, and arch supports then applied. Arch supports must conform to the contour of the foot, and to be of any real value must support the arch of the foot. They should, therefore, be made over a plaster-of-paris mold of the foot. A plaster cream is prepared and poured into shallow pans. While the plaster is still soft the foot is placed in it, no weight being borne and the arch preserved. The plaster is carefully molded about the inner border of the foot and the heel, and the foot allowed to remain until consolidation occurs. The mold is then smeared with vaselin and filled with fresh plaster cream, forming an accurate model of the sole of the foot. Arch supports may be made of steel, Monel metal, or alloys of various kinds. The author prefers, and has for many years used, a support made from leather, reenforced with cork and with a triangular metal plate under

Fig. 457.—Method of strapping for pes planus.

Fig. 458.—Arch support.

the arch proper. This type of support is resilient and permits muscle play; as the support is fitted to the foot, it finds and holds its place in the shoe so that no attachment is required and, therefore, may be changed from one shoe to another.

Steel supports are often necessary where there is extensive deformity. They are fashioned over a plaster mold of the foot and extend from the heel to the heads of the metatarsal bones, being carried upward along the inner border of the arch to the level of the tubercle of the scaphoid bone. The brace may be nickel-plated, which makes a smooth finish, or galvanized, which makes a more durable covering. It may be covered with leather, or an inner sole may be placed on its upper surface, but this is not usually necessary.

Whitman support.—The outline of the brace is drawn upon a plaster model and the brace cut from the best sheet steel, 18 to 20 gage, and molded to fit the bottom of the model. The sole part provides a firm, comfortable support, yet, reaching only from the center of the heel to just behind the ball of the great toe, it does not restrain the normal movements of the foot. There is a broad internal upright portion which covers and protects the astragaloscaphoid joint, rising well above the scaphoid bone; an external arm covers the calcaneocuboid junction and the outer aspect of the foot to a height sufficient to hold the foot securely. This brace clasps the weak part of the foot by two upright flanges and holds it together.

Roberts Support.—Metal plates which embrace the heel, as devised by Roberts, are often satisfactory for young children. This support is likewise molded over a plaster impression of the foot. It is based upon the theory that flatfoot is due to the rotation outward of the os calcis and is designed to maintain the upright position of the os calcis. The plate extends from the heel to the ball of the foot and the inner border of the foot is raised by tilting the floor of the plate under the os calcis. A thumblike flange engages and presses upon the tissues over the inner side of the os calcis near its posterior extremity. The corrected position in which the os calcis is held finally becomes the attitude of habit in the majority of cases, and it is usually possible to omit the support in about two years and occasionally earlier.

Shoes.—The question of proper shoes is more difficult to solve in adults than in children and in women than in men, as in the former protection must often be sacrificed for style. Generally speaking, laced shoes are to be preferred and in young children, high shoes are more effective than slippers or sandals. The shoe should be sufficiently long, the inner border straight, and the width amply wide to avoid crowd-

ing the toes. A heel is unnecessary in children's shoes as it limits use of the normal range of motion at the ankle joint. In adults, the heel makes walking easier by inclining the body slightly forward, but when too high, throws excessive strain on the forepart of the foot and crowds it forward into the narrowed part of the shoe. The fashionable French heel also affords a very small base for support and causes insecurity of the foot. The vamp of the shoe should be commensurate with the length of the forepart of the foot and the counter should grip the heel firmly to afford stability. Elevation of the inner border of the heel and sole of the shoe $\frac{1}{4}$ to $\frac{3}{8}$ inch may be all the treatment necessary in the young child and is often advisable in older children.

Surgical Treatment.—Operative procedures are indicated only in the very resistant cases when satisfactory results can not be obtained by other methods, and are to be advised in the following order for cases of correspondingly resistant deformity: (1) Manipulation of the foot under anesthesia with the application of a plaster-of-paris cast in the inverted position; (2) section of the peroneal tendons, as advised by Sir Robert Jones, followed by manipulation and casts; (3) transplantation of the calcaneoscaphoid ligament, and (4) arthrodesis of the astragaloscaphoid joint.

Miller Technic.—The author has found the operation of transplantation of the calcaneoscaphoid ligament, described by Miller, successful in a selected group of cases. An incision is made along the inner side of the foot from the os calcis, forward, over the bodies of the scaphoid and internal cuneiform bones, ending at the base of the first metatarsal bone. This exposes the calcaneoscaphoid ligament and the insertions of the posterior and anterior tibial tendons. After dissection of the subcutaneous fascia, a thin slab of bone from the side of the scaphoid and internal cuneiform bones is raised with a sharp chisel or osteotome, including the fanned-out insertion of the calcaneoscaphoid ligament and posterior tibial tendon. The joints between the astragalus and scaphoid, scaphoid and internal cuneiform, and internal cuneiform and the base of the first metatarsal bones, are thus exposed. The lesser articular ligaments are lifted upward and downward, subperiosteally, and preserved as well as possible to reapply over the area of fusion. The cartilage covering the scaphoid and internal cuneiform and internal cuneiform and head of first metatarsal bones is excised. The tendo achillis is also lengthened. If the neck of the astragalus is appreciably elongated, it may be shortened by talking out a section with an osteotome; the head can then be transplanted toward the middle of the foot. When the forefoot is adducted, the first metatarsal is rotated to a corrected

position. The slab of bone holding the insertion of the calcaneoscaphoid ligament and posterior tibial tendon is then pulled forward on tension and transplanted as a graft to the body of the internal cuneiform and base of the first metatarsal bone. This whole mass passes forward beneath the anterior tibial tendon, which is not disturbed at its insertion. The wound is closed, layer by layer, using chromic catgut beneath, and silk in the skin. After this procedure the scaphoid, internal cuneiform and base of the first metatarsal bones fuse to maintain their corrected relations. The calcaneoscaphoid ligament and posterior tibial tendon are made taut as they are transplanted forward, and this forms a substantial sling to keep the head of the astragalus directed into the normal weight-bearing line of the foot. A plaster cast is worn for six weeks and when removed, a short period of foot exercises and massage is instituted, and the patient begins supervised weight-bearing immediately, using a light metal arch support and a shoe of correct anatomical last.

HALLUX VALGUS

Excessive deflection of the great toe toward the outer side of the foot is called hallux valgus. The condition is usually associated with an enlargement on the medial aspect of the first metatarsophalangeal joint. This enlargement is called a bunion, and consists of a thickening of the bursa in this region, an exostosis on the bone, or a combination of both. Flattening of the transverse and longitudinal arches of the foot is frequently present.

Etiology.—Hallux valgus is more common in women than in men, and, while disability may not be produced until middle age, the affection usually begins in early life. The deformity is usually, though not necessarily, the result of improper shoes, but is said to occur rarely in barefoot races and in persons who have never worn tight shoes. It develops most often in those individuals whose occupation requires prolonged standing and walking. There is undoubtedly a familial tendency as several cases may be seen in a single family. Other predisposing factors are injury, gout, and the atrophic and hypertrophic types of infectious arthritis.

Symptoms and Diagnosis.—The great toe is abducted and there is a prominence on the inner side of the joint caused by the enlarged bursa, and the exostosis on the metatarsal bone. The extensor proprius hallucis tendon is contracted and displaced outward. The great toe, at times, may come to lie over or beneath the other toes, with complete dislocation of the metatarsophalangeal joint. The first metatarsal bone gradually becomes adducted and the space between the first and second

Fig. 459.—Bilateral hallux valgus.

Fig. 460.—Same as Fig. 459, after Mayo bunion operation.

metatarsal bones is widened. The skin overlying the joint becomes thickened, and the bursa may become inflamed causing an extensive cellulitis. In the advanced stage, pain, swelling and inflammation of the

bursa may cause extreme disability. The condition is usually bilateral. The diagnosis can be made on inspection; in addition there is progressive enlargement of the joint and continuous pain. The roentgenogram reveals hypertrophy of the distal end of the first metatarsal bone and the abducted position of the phalangeal bones. Hypertrophic or destructive changes may be present around the articular surfaces.

Treatment.—In mild cases, the deformity may be lessened by use of a properly fitted shoe; the shoe should be broad at the toe and the inner border of the sole straight. Pads and apparatus to correct the deformity are of little value. Operative treatment is required in all advanced cases and when expertly performed, the results are satisfactory and permanent. With ordinary care in protecting the wound these patients are often much better able to go about within two weeks than they were before the operation. It frequently occurs that they are not even kept in the hospital during the convalescence. Motion becomes nearly perfect. Of the numerous operative procedures devised for the correction of the hallux valgus, those described by Porter, Mayo, and Kellar are commonly employed. Other operative procedures have been devised, as osteotomy of the metatarsal bone, as suggested by Hohmann, and the plastic reconstruction of the ligaments of the internal lateral ligament of the first metatarsophalangeal joint, as described by Silver.

Porter Technic.—A crescent-shaped incision 2 inches long is made just below the edge of the callus which covers the enlarged head of the metatarsal bone. The capsule is incised in the same direction and to the same extent as the skin, and the capsule and periosteum are dissected free from the bone and retracted. Two thirds to three fourths of the head of the metatarsal bone is removed at such an angle as to include all of the enlarged tuberosity. After the bone has been removed and all the rough surfaces smoothed, the toe is pulled strongly inward and the tendon of the extensor hallucis longus, which is thus brought into prominence, is divided subcutaneously at the level of the joint. The toe can then, with very little pressure, be held straight. Occasionally the capsule on the outer side of the toe must be divided with a tenotome. While the toe is held in the corrected position a mattress suture of strong twenty- to forty-day catgut is placed in the capsule, being carried from the lower angle to the upper angle, returned through the upper angle and brought out at the lower angle. The suture is tied, thus approximating the upper and lower angles of the capsular incision, and if the proper amount of bone has been removed and the tendon divided, when that suture is tied, the toe will remain straight. The skin wound is closed and a dressing applied with a splint to maintain the corrected position of the toe.

Keller Technic.—The incision exposes the first metatarsophalangeal joint. The capsular ligament is incised and the structures at the base of the phalanx, including ligaments and periosteum, are pushed away from the articular surfaces; the phalanx is then disarticulated. With a Gigli saw, enough of the phalangeal head is removed to enable the distal portion to be placed in an overcorrected position medially, without impinging on the head of the first metatarsal bone. The exostosis is removed, but in order to preserve the sesamoid area, so essential to the integrity of the tripoid of the foot, the cut is made obliquely upward and outward along the length of the metatarsal bone. This cut extends from the inner edge of the sesamoid below, to a line above, which is well past the middle of the dorsum of the bone. The remains of the periosteum, capsular ligament, and other adjacent soft parts, are brought over the extremity of the resected phalanx by a figure-of-8 silkworm gut suture. A gauze drain is introduced through a stab wound in the lower lateral surface; the drain is inserted down to the joint space and is removed in forty-eight hours. A few figure-of-8 silkworm gut sutures bring the subcutaneous structures into apposition, and the wound is closed in the usual manner. An overcorrected position is maintained by means of a well padded lateral splint or bandages, and after five days passive motion is instituted. Active walking is not allowed until the end of the third week.

Mayo Technic.—The predominant feature of the Mayo bunion operation is based upon the operation of Heuter, and consists of excision of the head of the metatarsal bone. The great toe is shortened to a reasonable degree, somewhat narrowing the foot at its widest line, which is a factor of importance in the prevention of recurrence. The bearing surface on the under side of the joint is not disturbed and the cushion beneath with its sesamoid bones is left intact. A curved incision is made with the base downward over the inner side of the metatarsophalangeal joint, the skin being lifted in the flap which is separated from the bursa. A second incision with its base forward is now made around the bursa, leaving the base attached to the first phalanx, its inner surface being synovial membrane and continuous with the interior surface of the joint. The head of the metatarsal bone is removed with heavy bone forceps, the section also removing two thirds of the anterior portion of the bony hypertrophy on the inner side. The remainder of this projecting bone is cut away to the level of the metatarsal shaft. The cut end of the bone is made as smooth as possible by ronguer forceps and a file and the bursal flap turned into the joint area in front of the bone, where it is held in place by one or two catgut sutures. The bursa is thus utilized to secure

and maintain a movable joint, as in the operation of arthroplasty. The skin incision is sutured, and a splint applied holding the toe in slight flexion and adduction.

HALLUX VARUS

Hallux varus, or adduction of the great toe, is usually congenital in origin, and may be associated with a slight degree of varus of the forefoot. The condition may also occur in association with bowleg and coxa vara. The treatment in cases in which this deformity is combined with other deformities of the feet and legs is to correct the coexisting anomaly. Hallux varus alone does not generally require treatment, as the use of ordinary shoes is sufficient; when necessary, a simple apparatus may be employed to keep the toes parallel.

HALLUX RIGIDUS

Hallux rigidus is a condition in which there is a limitation of motion in the first metatarsophalangeal joint; dorsiflexion is most com-

Fig. 461.—Hallux rigidus.

monly restricted. Adults are more frequently affected than young individuals. In most cases the symptoms are probably due to arthritis, as there is usually an overgrowth of bone around the margins of the joint. The affection is characterized by an enlargement around the joint, limitation of motion in the joint, especially dorsiflexion, and pain, swelling, and congestion on overuse. The treatment during the acute stages consists of rest, with local application of wet dressings.

Great relief may be secured by an elevation just behind the head of the metatarsal bone; the elevation may be applied to an arch support or a cleat of leather, $\frac{3}{16}$ to $\frac{1}{4}$ inch thick and 1 inch wide, may be fastened to the sole of the shoe. Surgical treatment is necessary in resistant cases and consists of the removal of the exostosis, or a portion of the head of the metatarsal bone, as described in the treatment of hallux valgus. Less frequently excision of the sesamoid bones may be indicated.

METATARSALGIA
(Morton's Toe)

Anterior metatarsalgia is an affection characterized by spasmodic attacks of sharp burning pain, situated usually in the fourth, but occasionally in the second and third, metatarsophalangeal joints.

Etiology.—The condition is generally attributed to flattening of the anterior transverse arch of the foot, causing compression of the digital branches of the plantar nerves between the ends of the bones, but may be caused by contact between the heads of the metatarsal bones, abnormal strain upon the ligaments connecting the metatarsal heads, or chronic inflammatory changes in the flexor tendons and their sheaths. The condition is more prevalent in females and is extremely chronic. Narrow, tight, high-heeled shoes are undoubtedly a predisposing cause, as is also any fixed contracture of the tendo achillis which produces equinus of the foot.

Symptoms and Diagnosis.—The characteristic symptom is pain recurring in paroxysmal attacks, and definitely localized in the affected toe. The affection is most often unilateral, although both feet may be affected, in which case one side is usually more severe. The pain radiates into the toe, usually the fourth toe, and at times proximally into the foot and leg. The attacks ordinarily occur when the patient is standing or walking, but at times occur during a period of nonweight-bearing. The patient feels an urgent desire to take off the shoe, and soon learns that by removing the pressure and manipulating the toe the pain is relieved. The diagnosis is made solely upon the history of repeated attacks of pain. Physical examination of the foot, as a rule, is negative, although a flattening of the arch of the foot is apparent occasionally. There may be calluses on the sole of the foot under the metatarsal heads and the affected joint may be tender on pressure. The roentgenogram is negative. With proper treatment, the prognosis is good, but obstinate cases are seen which resist all methods of treatment.

Treatment.—Since the cause of the affection is a flattening of the metatarsal heads, the treatment consists of mechanical support of the

depressed arch. For temporary relief, strapping with adhesive plaster, combined with a felt pad behind the head of the affected metatarsal bone may give instant relief. Metatarsal pads attached to arch supports, or to a soft leather or elastic band are employed for continued use. In all instances, attention to proper fitting of shoes is important; high heels and narrow, short vamps are to be avoided. Removal of the distal end of the metatarsal bone may be necessary, but the operation should be cautiously advised, as relief in most cases may be obtained by persistence in the use of conservative measures.

CLAWTOE

Clawtoe is a deformity of one or more of the toes produced by contracture of the extensor tendons. The second toe is more commonly

Fig. 462.—Clawtoes

affected, and next in frequency the third, fourth, fifth, and first, respectively. The metatarsophalangeal joint is hyperextended; the proximal interphalangeal joint is flexed, and the distal interphalangeal joint may be plantarflexed or extended. The head of the metatarsal bone is depressed and prominent on the sole of the foot. Painful calluses develop over the proximal flexed knuckle under the metatarsal head and on the tip of the distal phalanx from pressure of the shoe.

Etiology.—Although the condition is classified as a static deformity, the etiologic factors vary. Improper shoes which throw excessive weight on the ball of the foot and prevent flexion of the metatarsophalangeal joints frequently produce the deformity. Other causes are imbalance between the flexor and extensor muscles of the foot from infantile par-

alysis and similar neurological affections; scar contracture of the soft structures from infections and burns; and arthritis of the metatarsophalangeal and interphalangeal joints. Low-grade infectious arthritis generally affects all the toes on both feet while in the static and neurological conditions, the contracture may be limited to a few joints. The condition is very disabling when heavy service is demanded of the feet.

Treatment.—The treatment, when the deformity is mild, consists of the wearing of properly shaped shoes with sufficient room to avoid crowding of the toes. In addition, an elevation behind the head of the metatarsal bone to induce flexion of the toes may be applied to an arch support or to the sole of the shoe.

In case of severe contracture of one toe (hammer toe), the patient will frequently request amputation, which, however, should be avoided. The operation to be performed consists of a wedge-shaped resection of the proximal interphalangeal joint. The toe may be completely extended if sufficient bone is excised, or a tenotomy of the extensor tendon may be necessary. The toe is held straight on a small splint until the bony surfaces fuse, which will produce a permanent cure. In very severe cases, when several or all of the toes are affected, the Hoffman operation is the method of choice, the technic of which is as follows: A curved incision is made on the plantar surface of the foot at the base of the toes; by dissection between the plantar tendons, the heads of all the metatarsal bones are exposed and excised. The author modifies this technic by several linear incisions on the dorsum of the foot parallel with the metatarsal bones. The dorsal tendons are lengthened and dissection is made to the heads of the bones; a sufficient amount of bone is excised to permit the toes to fall into anatomical alignment. Contractures of the phalangeal joints can usually be corrected by force after the wounds are closed. A splint of malleable metal is applied to maintain plantarflexion of the metatarsophalangeal joints and the phalangeal joints. The after-treatment consists in the employment of a support for the longitudinal and transverse arches, which should be worn for several months.

PIGEON TOE

A certain degree of varus of the forefoot is physiologic and normally present in the young child learning to walk. It is also one of the symptoms of weak feet in childhood, and, as a rule, should not occasion great concern, beyond the appropriate treatment for the weakness of which it is a symptom, as the slight pigeon toe will generally correct itself as the child grows older. Varus of the foot may be complicated by an inward torsion of the tibia, or the entire limb may be internally

rotated from the hip. When the attitude is habitual the sole of the shoe should be raised $\frac{1}{8}$ to $\frac{1}{4}$ inch on the outer front. Shoes thus modified, combined with training, will correct the faulty posture in the milder cases. If the deformity is persistent, a brace on both legs joined to a pelvic band may be required to rotate the limbs outwardly from the hip.

MARCH FOOT

March foot is a painful condition caused by overfatigue of a weak foot. There is an edematous swelling of the anterior metatarsal portion of the foot associated with spasm of the interosseous muscles, stasis of the blood and lymph, thickening of the periosteum, and brittleness of the bone tissue of the metatarsals. One or more of the metatarsal bones may be affected. The disease appears most often in the second and less frequently in the third and fourth metatarsals respectively; the first and fifth metatarsal bones are never affected. The roentgenogram shows no changes at the onset. Later, however, the shaft of the bone is thickened and the density of the bone in the affected region is decreased; still later a metatarsal fracture may occur without preceding trauma or even definite pain.

Fig. 463.—Fracture of second metatarsal bone in march foot.

Etiology.—The condition is frequently observed in soldiers or other individuals who are forced to walk long distances. According to Jansen, the cause is congestion of the fat with blood and lymph from foot strain. The condition is similar to spastic flatfoot. A sudden pull of the fibers of the interosseous muscles may separate the periosteum from the bone and cause a hemorrhage which presents itself as a spindle-shaped thickening along the bone.

Symptoms.—The symptoms are pain, swelling, and spasm of the intrinsic muscles of the foot. The pain is not severe, being described more as a feeling of stiffness in the forefoot. It is constant, however, on use, relieved by rest and may be caused by pressure over the affected area. The edema is present on the dorsum of the foot, on the plantar surface, and over the toes; the tarsal portion of the foot is rarely swollen. Spasm of the interosseous muscles is denoted occasionally by involuntary contractures of the toes. The roentgenogram, in the later stages,

shows a spindle-shaped enlargement along the metatarsal bone and often a fracture of the shaft.

Treatment is usually conservative. Properly fitted shoes, arch supports, and metatarsal pads to relieve pressure on the painful area are indicated. Physiotherapy in the form of baking and massage and exercises to strengthen the weakened muscles are of value.

SCOLIOSIS

Scoliosis, or lateral curvature of the spine, consists of permanent and fixed deviation of several or all of the vertebrae from their anatomical position in the median line. As the vertebrae under physiologic movements normally deviate to one of the other side of the midline of the body, the posture becomes pathologic only when the deviation becomes habitual and the erect attitude can not be resumed or persistently maintained.

Anatomy and Physiology of the Spine.—The spine is composed of the seven cervical vertebrae, twelve dorsal vertebrae, and five lumbar vertebrae, superimposed one upon another and supported below by the sacrum at the junction of the spinal column and the pelvis. The equilibrium of the trunk and the stability of the upright posture is maintained by the muscles which connect the spine to the upper and lower extremities, as well as by the muscles which are entirely axial in their attachment and function. The spinal muscles extend from the sacrum to the occiput, forming a cylindrical mass on either side of the vertebrae from the loin to the base of the skull. In the section on Examination of the Spine, it has been stated that the normal movements of the spine are flexion, extension, side-bending, and rotation. Side-bending and rotation, however, are inseparably associated. As the spine is bent laterally, the intervertebral disks are compressed to a slight degree on the concave side, and expanded proportionately on the convex side. The disks, however, are compressible to a very minor degree only, and in order to permit greater flexibility, the vertebrae rotate, one upon another, the body of the vertebra rotating toward the convexity. The amount of rotation naturally is greatest at the apex of the curve and proportionately less at the extremes of the curve. Since the contour of the spine is dependent upon the static demands of weight-bearing, a change from the normal relation of one part, produces a corresponding or compensatory change in the opposite direction in another region of the spinal column to restore the balance of the body. In some instances, the entire spine may be curved to one side, causing a single long curve or a total scoliosis in one direction.

Age at Onset.—The incidence of scoliosis in children of school age has been estimated as being 20 to 30 per cent. Obviously, the age at onset is difficult to determine accurately, because in a majority of cases the deformity is discovered accidentally at a time when it is well developed, and it is impossible to estimate how long it has been present. Scoliosis is often first noticed when the back is examined, following some minor injury, or in the case of girls when clothing is being fitted. In a study of 125 cases by Mitchell, the average age at which the deformity was first noticed by the family was twelve and a half years in both male and female patients. The age at which the physician was first consulted, however, was fourteen years for girls and eighteen years for boys. Ten patients were under ten years of age; 97 were in the second decade of life; 15 in the third decade, and 3 were past the age of forty. Females are affected more frequently than males in the ratio of seven to three.

Etiology.—In the study of any large series, scoliosis will readily fall into two groups. First, those which are called idiopathic, to which no definite etiologic factor can be attributed; and, second, those in which the direct cause is obvious, for example, anterior poliomyelitis, congenital anomalies of the spine, or empyema. The etiology of scoliosis, especially of the static or idiopathic variety, is obscure. According to Lovett, the condition originates in the flexed position of the spine, and the immediate cause is some asymmetry of development or posture which leads to the superincumbent weight of the upper part of the body being borne in an oblique direction on an unstable spine, thus causing the spine to deviate from the midline. Any faulty attitude habitually assumed by the growing child will result in uneven distribution of the weight and is the direct cause of the deformity.

The predisposing factors are varied, and many theories have been suggested. For example: (1) It has been claimed that all cases are due to unrecognized poliomyelitis which may have involved only the spinal muscles. (2) Redard believes that the large incidence of flatfoot coincident with scoliosis suggests the general loss of muscle tone as an etiologic factor. Brackett, Scudder, and others have emphasized the laxity of the spinal ligaments, the muscular weakness and the decreased density of bone. (4) Lee accounted for the high incidence of the condition in girls at puberty as being due to stimulation of the sacral plexus by pelvic congestion. (5) In the series of cases reported by Adams, there was a large percentage with congenital variations of the lumbosacral spine. (6) Vertebral epiphysitis as shown roentgenologically by a disturbance of the epiphyseal areas of the vertebrae, is frequently seen

in scoliosis and is regarded by some authorities as a contributing factor in the production of the deformity.

Idiopathic Scoliosis.—The postural or idiopathic group is by far the largest in number, comprising about 60 per cent of the total in the series which have been reported. There is also a greater relative frequency in young girls in this group. While approximately 70 per cent of all cases occur in females, in the idiopathic group, about 80 per cent are females. In idiopathic scoliosis the chief symptom is the deformity. The diagnosis can be made only by exclusion, as there is nothing characteristic either in the type or in the severity of spinal deformity. The deformity varies from mild to extreme curvatures in all regions of the spine, both total and S-shaped curves being found. The typical deformity seen in adolescent girls, however, is a moderately advanced curve in the dorsolumbar region, with compensatory curves above or below. As a rule, this group responds more favorably to treatment than the other group, the curvature being easier to correct and maintain.

Paralytic Scoliosis.—Scoliosis is a frequent complication in anterior poliomyelitis, occurring in about 30 per cent of old cases. The cause is usually unilateral weakness of the muscles of the spine or abdominal wall, but may be paralysis of one of the upper extremities, or paralysis with contracture of the lower extremities. The deformity in paralytic scoliosis is often extreme, and consists of a total curve or one large curve and a smaller compensatory curve. Pain is a frequent symptom, being caused by impingement of the ribs on one another or on the pelvis. The deformity in advanced cases is difficult to correct or to maintain in even the slightest degree of improvement.

Congenital Scoliosis.—Minor congenital anomalies of spinal development are a frequent finding in association with lateral curvature, and undoubtedly are reported with greater frequency on roentgenological examination in this condition than in patients without scoliosis. Of the spinal anomalies, spina bifida occulta of the last lumbar and first sacral vertebrae occurs most frequently. Other findings are numerical variations of the vertebrae, asymmetry of the lumbosacral articulation, enlargement with or without sacralization of the transverse processes of the fifth lumbar vertebra, wedging of the bodies of the vertebrae, and cervical ribs. Severer and more obvious spinal defects are sometimes present; absence of a portion of a vertebra, numerical variations in the ribs, especially when unilateral, and gross malformation are indisputable causes of scoliosis.

Empyema.—Pneumonia and empyema in early childhood may be followed by collapse of the lung, resulting in scoliosis. The deformity

in this group may be great, and is resistant to treatment because the collapsed lung can not be made to expand the chest wall.

Associated Conditions.—Various conditions have been noted in association with scoliosis, some of which are dependent upon the same etiologic factor as the spinal deformity; none should be considered as etiologic factors in themselves, because the relative frequency of each is small in comparison with the total number of cases. Inequality in the length of the legs, varying from $\frac{1}{4}$ to $\frac{3}{4}$ inch, is a frequent observation. It is not uncommon to find an otherwise normal person with shortening on one side. On the other hand, in extreme scoliosis there may be no inequality. In many

Fig. 464.—Congenital anomaly of spine.

Fig. 465.—Paralytic scoliosis.

instances with extreme inequality, as in infantile paralysis, there is no fixed deformity of the spine; there is a tilting of the pelvis when the patient stands and a compensatory lateral curvature of the spine which disappears, however, on sitting or lying. Scoliosis, therefore, is not caused solely by inequality in length of the legs. Flatfoot may be associated with scoliosis, but is rarely severe enough to be a contributing factor. Kyphosis, round shoulders, and increased lumbar lordosis may be observed in a small percentage of

cases, and when present are often associated with an osteochondritis or epiphysitis of the spine.

Pathology.—The pathologic changes in scoliosis are not those resulting from destructive disease of the vertebrae, but are simply the alterations in shape of the bones induced by abnormal pressure and strain. The body of the vertebra becomes distorted, thicker on the convex side and thinner on the concave side. The vertebra also becomes twisted about an axis, passing through the neural canal, the body and spinous process curving toward the convex side. The neural arch is asymmetrical, the lamina and pedicle on the convex side being shortened and the spinous process and body approaching the transverse process on that side. The greater changes occur in the vertebrae near the apex of the deformity and there is a gradual transition from the normal in the other vertebrae. The ribs, in affections of the dorsal region, are distorted by the deviation of the vertebrae and accentuate the apparent rotation in this portion of the spine. The contour of the thorax is altered; there is a sharp backward prominence near the angle of the ribs on the convex side and a prominence forward on the side of the concavity. The ribs lie closer together and the costal margin on the concave side approaches or comes in contact with the iliac crest. When the upper dorsal region is affected, the shoulder on the convex side is elevated, and when the lumbar spine is involved, the anterior superior spine and iliac crest on the concave side become prominent. The ligaments and muscles on the concave side become permanently shortened and those on the convex side elongated. In cases of long standing, the stretched muscles degenerate. Distortion of the skeleton produces pressure upon the thoracic and abdominal viscera and consequent interference with their physiologic functions.

Symptoms.—The symptoms vary somewhat with the etiology. They are mild at onset, and often the deformity is the only complaint. This, however, is usually progressive. In the idiopathic group, the children are often tall and slender, slightly undernourished and growing rapidly. They may complain of tiring easily on exertion and of having a dull backache, which is at times referred to the pelvic or shoulder girdle. There may be awkwardness in walking, shortness of breath and nervousness. Cardiac irregularity and tachycardia are sometimes noted.

Examination.—The special points to be observed in the examination of the spine in scoliosis are the location and degree of the lateral curves and the amount of rotation of the vertebrae. When the thoracic vertebrae are rotated, the ribs become prominent on one side posteriorly and on the opposite side anteriorly. Rotation of the vertebrae is best

demonstrated by flexion of the spine, as this accentuates the prominence of the costal angulation in the thoracic region and the loss of the normal lumbar depression on the convex side in the lumbar region. The shoulder on the convex side is usually higher. Any tilting of the pelvis should be noted and the length of the legs should be compared. The strength of the spinal muscles should be tested. Motion of the spine in the direction opposed to the deformity is usually limited. The amount of correction obtained by voluntary effort should be noted and also the improvement by forward bending and by suspension. A record should be made of the curvature before treatment is begun. This may be done

Fig. 466.—Scoliosis of static type.

Fig. 467.—Same as Fig. 466, after correction.

by a tracing of the curve from a lead tape bent to correspond to the deformity, or by a carefully posed photograph. A roentgenogram of the entire spine should always be made and is probably the best record available.

Roentgenoscopy.—The roentgenogram in the early stage shows the curvature with narrowing of the intervertebral spaces on one side. In cases of long standing, there may be marked wedging of the vertebrae and associated torsion of the pedicles, laminae, and processes. In many, the roentgenogram shows a pathologic lesion in the bone which may resemble, to some extent, the epiphysitis of coxa vara, discussed under

epiphysitis of the spine. The purely destructive lesions of the spine, such as tuberculosis, osteomyelitis, and syphilis, are readily differentiated by the roentgen ray by the excessive amount of destruction. As destructive lesions usually involve the bodies of the vertebrae, the resulting deformity is a kyphos, and rarely a lateral distortion.

Diagnosis.—The diagnosis of scoliosis is evident by inspection of the spine and rarely will be confused with other affections. The deformity

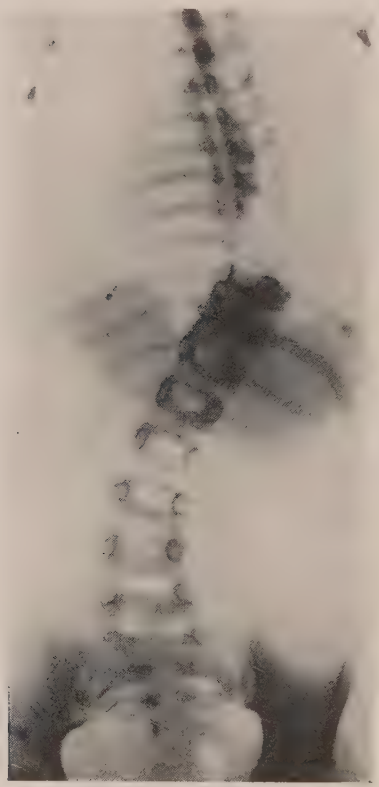


Fig. 468.—Scoliosis, with rotation of bodies of vertebrae.

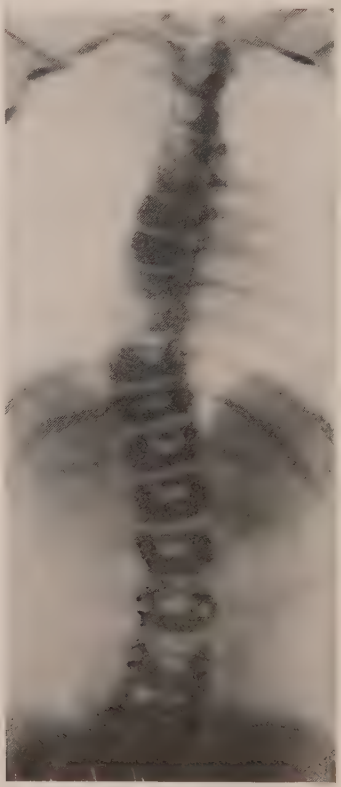


Fig. 469.—Same as Fig. 468, after correction by turnbuckle cast. Note straightening in both dorsal and lumbar areas; also decrease in rotation of bodies of vertebrae.

is a lateral curvature, associated with rotation of the vertebrae and bulging of the ribs which is accentuated on forward bending. The differentiation from tuberculosis is perhaps the most important. The diagnosis is made by the greater severity of pain in tuberculosis, with muscle spasm and rigidity of the spine. As previously mentioned, the deformity in tuberculosis is usually a kyphos. The roentgenogram is

also an aid in differentiation by showing the erosion of the adjacent surface of the vertebrae.

Prognosis.—The prognosis for improvement is favorable in most cases, if the condition is recognized early. With appropriate treatment, the process may be arrested and severe deformity prevented, and often the spine may be held practically straight. However, the deformity may progress regardless of every form of treatment, and when the curvature is well advanced, normal symmetry of the body can never be restored.

Treatment.—The importance of early and efficient treatment of patients with scoliosis, arises from the extreme uncertainty of their future progress. It is known that in some cases, the condition may become spontaneously arrested in an early stage; in others, the disease may progress and may not only produce extreme deformity but seriously impair the general health. The aim of treatment should be to prevent the progress of the deformity, to correct, if possible, the existing deformity and to maintain the correction until all danger of relapse is passed. This usually means the wearing of apparatus until maturity. The correction of spinal curvature requires close attention to detail, and careful adaptation of the various procedures to the individual, varying largely with the location and degree and, to a lesser extent, with the etiology of the deformity. With the introduction of ankylosing operations on the spine, interest in the treatment of scoliosis has been greatly stimulated. Fusion of the affected region of the spine offers a practical and efficient method of preventing the increase of the deformity, and when combined with thorough preoperative correction, gives a more definite goal toward which both patient and surgeon may strive than can be anticipated in the majority of cases in which conservative methods of treatment alone are used. Many methods for correction of spinal curvature have been described, five of which have been found of common usefulness. (1) Traction on a convex frame, as advocated by Whitman. (2) The turnbuckle cast described by Lovett and Brewster. (3) The cast applied with head and pelvic traction on a special frame devised by Hibbs. (4) The cast applied with the spine in flexion or the method which was popularized by Abbott. (5) The cast applied on a special apparatus described by Galeazzi. Since the upright position favors the progress of the deformity, recumbency is an important factor in treatment. Continuous recumbency is of course essential to the Whitman method, but when practicable, should be enforced also for the patient being treated by the turnbuckle or other type of cast. When it was not possible to maintain continuous rest in bed, long rest periods daily are advisable.

Traction on Convex Frame.—For traction, as advocated by Whitman, the patient is placed upon a Bradford frame, which is curved opposite the point of greatest deformity of the spine. Traction to the head is applied with a Sayre halter and to the lower part of the body by Buck's extension or a pelvic band. Beginning with 4 to 6 pounds to each foot, and the same to the head, the weight is gradually increased. A canvas band is placed around the thorax at the point of greatest curvature and a pull made toward the concave side through a pulley on that side of the bed. This weight may be gradually increased to 25, or even 40 pounds, as it is surprising how little discomfort is experienced by the constant pressure of such force. The position of hyperextension of the spine exerts a direct extending force on the spine by separation of the vertebral bodies, and also has the advantage of increasing the lateral diameter of the chest. The pressure on the back tends to lessen the convexity of the ribs, to push them forward and thus to expand the chest on the contracted side. The treatment should be continued for a period of six to eight weeks.

Fig. 470.—Turnbuckle cast used in correction of scoliosis.

The Turnbuckle Cast.—Satisfactory results may be obtained in suitable cases with the turnbuckle cast described by Lovett and Brewster. As designed by the originators, it is most efficient in those cases in which there is a single curve at the dorsolumbar region. However, in cases of double curvature, it has been demonstrated that by correcting the dorsolumbar curve, compensatory curves above and below may be lessened. This cast is applied in the following manner: The patient is suspended; the bony prominences are well padded and a snugly fitting plaster-of-paris cast is applied. If the curvature is in the lumbar region, it is well to include the thigh on the concave side. The cast is allowed to set, and is then cut down the center front and removed. At the point of greatest deformity, it is cut transversely; an ordinary garden-gate hinge is fastened on the convex side and two turnbuckles are fastened to the concave side; straps and buckles are applied down the front.

When completed the cast is replaced on the patient. The turnbuckles are tightened a few times each day and the deformity is gradually corrected. If necessary, a second and a third cast may be applied in the same manner until the maximum amount of correction is obtained.

Hibbs Technic.—The cast from chin and occiput to pelvis, applied under traction on a special frame, described by Hibbs, is undoubtedly the most efficient method for correcting high dorsal curves. The apparatus consists of a rectangular frame to which is attached a ratchet at either end for direct traction, and an attachment with canvas hammock

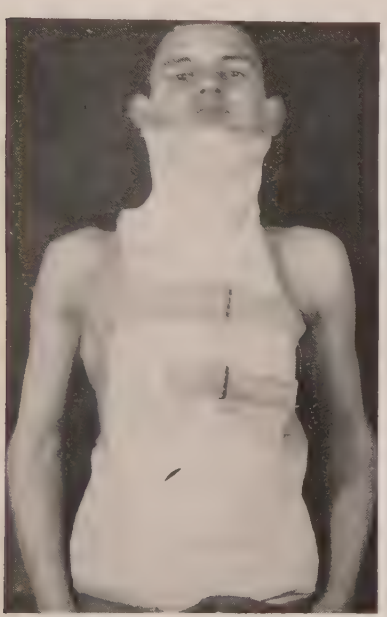


Fig. 471.—Plaster-of-paris cast applied on Hibbs' frame. Anteroposterior view.

Fig. 472.—Same as Fig. 471. Lateral view.

for supporting the body during the application of the cast. The patient is placed upon the hammock and a canvas belt is fastened about the pelvis with canvas strips on either side which are attached to the ratchet at the foot of the frame; a halter is applied to the head for traction by the ratchet at the head of the frame. A direct extending force is thus applied to straighten the spine. According to Hibbs, the amount of force that can be borne without serious discomfort is great—from 60 to 100 pounds. The bony prominences are well padded and a plaster cast from the chin and occiput above to the pelvis below, is applied while the spine is extended, being molded to conform accurately to the brim of the pelvis.

When the cast has solidified, a large window is cut over the lateral aspect of the thorax on the concave side and lateral traction instituted by means of a canvas band incorporated at the time of the application of the cast. The cast may be changed at intervals of two or three weeks and the amount of correction of the spine may be checked by a series of roentgenograms through the cast.

Abbott Method.—The patient is placed upon a special frame with the spine flexed and rotated in the direction opposite that of the deformity. Lateral traction and countertraction are made by canvas strips and a cast applied. Later, windows are cut in the cast, one large window being over the contracted thorax on the concave side to allow for expansion of the contracted chest, and other smaller windows on the convex side, through which felt pads are drawn. The thickness and number of the pads are gradually increased as the deformity is lessened.

Fig. 473.—Leather corset reinforced with steel to be used after maximum correction has been obtained in treatment of scoliosis.

Galeazzi Technic.—The method of correction suggested by Galeazzi consists of the application of a plaster cast with the spine rotated into the position of correction in a special apparatus devised by him. The patient is placed in the apparatus with the trunk horizontal and the hips and shoulders flexed. The apparatus permits independent rotary movement of the upper and lower ends of the spine, around a vertical axis, which accomplishes lateral flexion, rotation and torsion of the spine. The upper and lower segments of the spinal column are incorporated separately in a plaster-of-paris cast, and when correction of the primary curve is accomplished, the two halves of the cast are united and the patient removed from the apparatus. The casts are changed every three months, and the total duration of the treatment is from eighteen months to three years.

Braces.—In many cases, when the maximum degree of correction has been secured, the improved position may be maintained by apparatus. Modifications of the Taylor and Steindler braces are most suit-

able. For the high dorsal curves, a head support must be attached to the brace. In addition to the various standard spinal braces, an apparatus based upon the same principles as the turnbuckle cast, has proved efficient in maintaining the correction in the lower dorsal and lumbar regions. A plaster-of-paris model of the trunk is made and removed immediately; when thoroughly dry, it is cut transversely at the level of greatest deformity. The segments are then separated on the concave side similar to the turnbuckle cast. A few turns of plaster bandage hold the model in this corrected position. The form is then filled with plaster cream, and a torso of the patient is secured in the corrected position. Over this torso a leather corset is made which is reinforced with

Fig. 474.—Paralytic scoliosis.

Fig. 475.—Same as Fig. 474, after correction and fusion of spine.

steel strips. This brace is comfortable and easily removable for bathing and exercises.

Surgical Treatment.—Operative fusion in many cases is the method of choice. The two classical methods of spinal arthrodesis, the Albee graft and the Hibbs fusion both present technical difficulties in a scoliotic spine. The straight rigid Albee graft is not adaptable to the curve of the deformity. In Hibbs' operation, the laminae and articular facets on the concave side are difficult to expose. An osteoperiosteal graft from the tibia is the most satisfactory procedure. This graft may be combined with a simplified Hibbs operation and supplies a large mass of new bone which is flexible and easily accommodated to the area of deformity. In cases with prominences of the ribs, a portion of a rib

may be resected and used as an additional graft in combination with the Hibbs fusion. As in all operations on the spine, fusion is often accompanied by some degree of postoperative shock. This can be best prevented by the preliminary adjustment of the patient in the prone position on sandbags, so that the respiration, already limited by the deformity, is not further impaired.

ROUND SHOULDER

Round shoulder is one of the common postural deformities of childhood and adolescence. This position is one of weakness, and, like scoliosis, is most frequently seen in girls about the age of puberty. The normal kyphos of the dorsal region of the spine is increased and the lordosis of the lumbar spine is decreased so that the entire spine assumes a rounded contour.

Fig. 476.—Round shoulder and hollow back posture.

Symptoms.—The chief symptom is the deformity. In addition, a sense of fatigue may be apparent more readily than in normal individuals. This tiring may be associated with pain in the scapular and lumbar regions and the patient's general physical condition is usually below normal. The deformity consists of a rounded kyphos, which is more marked in the dorsal region of the spine, with prominence of the scapulae. In the early stages this faulty position may be corrected and the normal erect posture assumed at will, but as the condition becomes habitual and the structures more rigid, the range of motion in extension becomes limited and deformity is more or less fixed. Flexion and side bending of the spine are usually not restricted. The examination may show the association of other static conditions, such as flatfoot. The roentgenogram shows narrowing of the intervertebral spaces which may closely resemble low-grade spondylitis; roughening of the vertebral epiphyses may also be apparent, as in scoliosis, because vertebral epiphysitis is frequently a predisposing factor in all static affections of the spine.

Diagnosis.—The diagnosis is usually obvious on inspection, tuberculosis of the spine being the only affection with which it may be confused. The differentiation from tuberculous spondylitis is made by the angular character of the kyphos in tuberculosis, in which one spinous

process is unusually prominent. In round shoulder, the kyphos is curved and there is no definite knuckle. Pain is rarely present in round shoulder, and when present, is not severe. In tuberculosis, pain is the earliest symptom, persists constantly and gradually increases in severity. The prognosis depends upon the early recognition of the affection. With prompt institution of efficient treatment, much subsequent deformity may be prevented.

Treatment.—The treatment should consist of measures designed to induce normal physiologic posture—head erect, shoulders thrown back, chest expanded, and the abdomen retracted. Deep breathing exercises and exercises to strengthen the spinal muscles are of value. In those cases in which the deformity is progressive, a light form of spinal brace may be indicated. In the severe cases, corrective procedures may be necessary, such as traction to the head and the lower extremities on a curved Bradford frame, or gradual correction in a modification of the turnbuckle cast. Attention must also be directed toward improving the general health by such methods as tonics, outdoor exercises, and general hygienic measures.

HOLLOW BACK

In hollow back there is an exaggeration of the lumbar lordosis. The condition is less common than kyphosis and is usually secondary to other abnormalities of the spine or lower extremities, such as flexion contracture of the hips, congenital dislocation of the hips, spondylolisthesis, or affections of the nervous system. The treatment should consist, first, of correction of the primary deformity which will usually result in the correction of the hollow back. In certain instances in which symptoms are not relieved by such measures, a light spinal brace or properly fitted corset with abdominal support may be indicated.

VISCEROPTOSIS

Visceroptosis is a sagging of the abdominal viscera in the peritoneal cavity, often associated with static deformities of the spine, as round shoulder and hollow back. The segments of the alimentary canal are most frequently displaced, but the spleen, liver, and one or both kidneys may also be freely movable. Weakness of the abdominal muscles is a predisposing cause, and exaggerated cases are sometimes seen following repeated pregnancies, and after paralysis of the abdominal muscles in anterior poliomyelitis. Two types of individuals are recognizable, the slender type and the stocky type. Visceroptosis occurs usually in those of the former group. Women are more frequently affected than men.

The symptoms are referable to the displaced organs and usually consist of digestive disturbances, constipation, flatulence with pain, weakness in the back, and inability to perform the usual duties. The diagnosis may be made from the symptoms but, as a rule, fluoroscopic or roentgenological examination following a barium meal is required for confirmation. All cases, particularly the paralytic, may be benefited by the application of properly fitted abdominal supports, and close attention to the restoration of normal body posture.

BIBLIOGRAPHY

Abbott, E. G.: Correction of Lateral Curvature of the Spine, New York Med. Jour., 95 : 833, 1912.

Adams, Z. B.: The Relation of Bony Anomalies of the Lumbar and Sacral Spine to the Causes and Treatment of Scoliosis, Jour. Orthop. Surg., 12 : 45, 1914.

Brackett, E. G.: An Etiological Factor in Lateral Curvature, Trans. Amer. Orthop. Assoc., 9 : 207, 1896.

Davis, Gwilym George: Applied Anatomy, Ed. 5, Philadelphia, Lippincott Co., 1918.

Galeazzi, Riccardo: The Treatment of Scoliosis, Jour. Bone and Joint Surg., 11 : 81, 1929.

Goldthwait, J. E.: Obliteration of the Anterior Transverse Arch of the Foot as a Cause of Metatarsalgia, Boston Med. and Surg. Jour., 132 : 564, 1895.

Heuter: Quoted by Holmes, T.: System of Surgery, Philadelphia, Henry C. Lea's Son and Co., 3 : 372, 1882.

Hibbs, Russell A.: A Report of 59 Cases of Scoliosis Treated by the Fusion Operation, Jour. Bone and Joint Surg., 6 : 3, 1924.

Hoffman, P.: An Operation for Severe Grades of Contracted or Clawed Toes, Amer. Jour. Orthop. Surg., 9 : 441, 1911–1912.

Hohmann, G.: Ueber Hallux Valgus und Spreizfuss, Arch. of Orthop., 21 : 525, 1922–23.

Jansen, Murk: March Foot, Jour. Bone and Joint Surg., 8 : 262, 1926.

Jones, Robert: Orthopedic Surgery (Jones and Lovett), New York, William Wood and Co., 1923, p. 616.

Keller, William L.: Further Observations on the Surgical Treatment of Hallux Valgus and Bunions, New York Med. Jour., 95 : 696, 1912.

Lee, Benjamin: The Nervous and Muscular Element in the Causation of Idiopathic Lateral Curvature, Trans. Amer. Orthop. Assoc., 3 : 80, 1890.

Lovett, Robert W.: The Mechanics of Lateral Curvature of the Spine, Trans. Amer. Orthop. Assoc., 13 : 251, 1900.

Lovett, R. W., and Brewster, A. H.: The Treatment of Scoliosis by a Different Method from that Usually Employed, Jour. Bone and Joint Surg., 6 : 847, 1924.

Mayo, Charles H.: Collected Papers by the Staff of St. Mary's Hospital, Mayo Clinic, Rochester, Minn., 1905–1906, p. 561.

Medical War Manual No. 4, Military Orthopedic Surgery; The Soldier's Foot and the Military Shoe, Prophylaxis, 1918, p. 31.

Miller, Oscar Lee: A Plastic Flat-Foot Operation, Jour. Bone and Joint Surg., 9 : 84–91, 1927.

Mitchell, Joseph I.: The Etiology and Treatment of Scoliosis, Arch. Surg., 16 : 680, 1928.

Morris, Henry: The Anatomy of Joints of Man, London, J. and A. Churchill, 1879.

Porter, John L.: Some Further Notes on the Treatment of Bunions, Surg., Gynec. and Obst., 26 : 460, 1918; Why Operations for Bunion Fail, with a Description of One That Does Not, Surg., Gynec. and Obst., 8 : 89, 1909.

Redard, P.: De La scoliose dans ses rapports avec le pied plat, Trans. Amer. Orthop. Assoc., 9 : 339, 1891.

Roberts, Percy Willard: Prevention and Treatment of Weakfoot in Children, Jour. Amer. Med. Assoc., 75 : 237, 1920.

Scudder, Charles L.: A Determination of the Muscular Strength of Growing Girls and Its Relation to the Etiology, Treatment, and Prognosis of Lateral Curvature of the Spine, Trans. Amer. Orthop. Assoc., 3 : 84, 1890.

Silver, David: The Operative Treatment of Hallux Valgus, Jour. Bone and Joint Surg., 5 : 226, 1923.

Whitman, Royal: Orthopedic Surgery, Ed. 6, Philadelphia, Lea and Febiger, 1919, p. 687.

Whitman, Royal: Observations on the Operative Treatment of Scoliosis, Jour. Orthop. Surg., 3 : 330, 1921.

CHAPTER XVIII

CONGENITAL ANOMALIES

Congenital anomalies and deformities are affections of prenatal origin, the cause of which is largely speculative. Errors of development may arise from an inherent peculiarity, weakness, or disorganization of the germ cell, as is evidenced by their transmission through several generations. Anomalies may also be due to constriction by amniotic bands, and to the position of the fetus in utero. The theory of prenatal suggestion through fright or mental impression is a superstitious invention of the ignorant which has been passed from generation to generation, but can not be substantiated by scientific fact. As this theory has been accepted for centuries, many members of the medical profession still regard prenatal influence as a factor. There also exists in the mind of the laity the fallacious impression that syphilis in some ancestor is responsible for deformities in children. The Wassermann test is positive in about the same percentage in children with congenital deformities as in any other group, and syphilitic stigmata are not observed more frequently. Heredity plays a part, but many deformities are observed in the children of healthy parents from whom no family history of former occurrences can be obtained. However, people are often sensitive regarding congenital anomalies, and their reticence may have prevented such knowledge from passing to their descendants. For convenience in description, congenital anomalies may be classified as follows: (1) Atrophic, (2) hypertrophic; (3) numerical variations, and (4) distortions of normal structures. However, two or more of these conditions may be associated in the same individual.

Atrophy may be local or general. There may be local atrophy of a finger, toe, or an entire extremity, without defect in the component parts. Hemiatrophy or unilateral asymmetry is a deficiency in growth of one lateral half of the body, so that when full growth is attained the face on one side is much smaller and the extremities much shortened. General atrophy is synonymous with dwarfism. No treatment is of any practical value except to compensate by prosthetic appliances.

Hypertrophy may be diffuse in oversized individuals but is of no special significance. Local hypertrophy may involve one finger, toe, hand, or the entire extremity, the part becoming three or four times the normal size. The condition is due apparently to rapid proliferation of embryonic tissue, or tissues which have not fully matured, and is, in a measure, related to neoplastic growth. Hypertrophy may also be caused by actual tumors; neurofibromata may induce a condition closely resembling congenital hypertrophy. The hypertrophied part, particularly if the lesion is in the lower extremity, may become distorted by functional use. Amputation may at times be indicated, but improvement can often be accomplished by excision of the hypertrophied structures and reconstruction of the soft tissues and bone.

Fig. 477.—Congenital bilateral absence of radius.

Fig. 478.—Congenital amputation of forearm.

Numerical Variations.—Numerical variation is an increase or decrease in the normal number of anatomical parts. Complete absence of a part is often observed, as congenital amputation of a limb. There may be partial absence of the constituent units, or there may be supernumeration with increase in number. One or more of the phalanges of the toes or fingers, or of the metatarsal or metacarpal bones may be lacking. In the leg the entire tibia may be absent; this is of frequent occurrence and produces a characteristic distortion. The foot is usually clubbed and folded against the inner aspect of the leg. The fibula becomes markedly hypertrophic and bowed outward, and at the upper extremity is displaced upward; the leg may also be folded against the inner aspect of the thigh. The leg below the knee is much shorter than normal and may be

a mere appendage. The only treatment for such conditions is surgical; the fibula is shifted by a two-stage operation to articulate with the knee and ankle. Compensatory hypertrophy of the fibula then occurs, but the limb is always much shorter, an approach to normal is never to be

Fig. 479.—Hands showing sixth finger on each hand.

expected, and prosthetic apparatus are always necessary. Absence of the fibula is not so disabling as absence of the tibia, because the entire knee joint and a greater portion of the ankle joint is present. Congenital absence of a bone is always associated with contracted muscles and soft

Fig. 480.—Same as Fig. 479, after removal of supernumerary finger.

structures. In the thigh, there may be partial or complete absence of the femur with the leg attached as an appendage at the hip. In such cases, only prosthetic appliances are of benefit; surgery offers very little hope of improvement. Congenital absence of an entire vertebra or part of a vertebra may be observed in the spine, or there may be super-

numerary vertebrae, as six lumbar vertebrae. Again, there may be hypertrophy of certain processes, as the transverse process of the seventh cervical, the so-called cervical rib, which may cause serious pressure symptoms in young adults. During childhood the process is composed largely of cartilage and symptoms are never manifested. The transverse process of the fifth lumbar is often enlarged and may in later life press upon the wing of the sacrum and produce low back pain. Scoliosis is often associated with anomalies of the spine, or is caused by them, as

Fig. 481.—Congenital absence of fibula, with compensatory hypertrophy of tibia. Anteroposterior view.

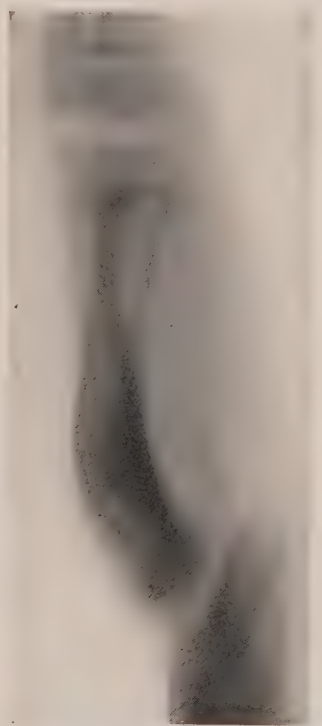


Fig. 482.—Same as Fig. 481. Lateral view.

the superincumbent weight increases. In the upper extremities, congenital absence of the radius is frequent. The hand is deviated inward, the ulna is bowed outward and the radial muscles shortened. Supernumerary digits are often associated, or there is an absence of the thumb or fingers. Congenital absence of the ulna is exceedingly rare, the deformity being the reverse of that observed in congenital absence of the radius. The extremity is materially shortened. Conservative treatment by splints is employed until the child is two years of age. At

that time operative procedures for transplantation of bone are indicated. The final result is always a much shortened and defective member.

Distortion of Normal Structures.—Deformity and distortion of normal structures are probably more common than atrophy, hypertrophy, or deficiency. Not all deformities will be considered, but only those of more common occurrence. The description of congenital deformities will begin with the feet. Congenital deformities of the feet are called talipes, and may be classified as equinus, calcaneus, varus, valgus, and the combined forms, as calcaneovarus, and calcaneovalgus, etc.

TALIPES EQUINOVARUS
(Clubfoot)

The most common congenital deformity occurring in the feet is talipes equinovarus, clubfoot, or reel foot. All the bones and soft structures of the foot are present, but are distorted in their relations to each other. The condition may be due to deficiencies or contractions of the soft tissues from position in utero. As in other congenital anomalies, talipes equinovarus may be unilateral or bilateral.

Pathology.—As the term implies, the forefoot is turned in, the heel is drawn upward, and the foot is fixed in inversion and plantarflexion. The outer border of the foot is prominent and overdeveloped, while the inner side is concave, compressed, and underdeveloped. The bones of the tarsus are distorted to conform to this position, which becomes more pronounced and fixed as age advances. The astragalus is extended at the ankle joint, subluxated forward, and the anterior portion of the upper articular surface is often broader than the mortice between the tibia and fibula. This is a frequent cause of failure in correcting the equinus deformity. The neck of the astragalus is rotated and the head displaced inward. The long axis of the os calcis, instead of being directed horizontally, extends downward, forward, and inward. The bone also is rotated about this axis so that its inner surface is directed upward. The cuboid, the scaphoid, the cuneiform bones, and the metatarsal bones are displaced medially with the astragalus and os calcis, but are, as a rule, not altered in shape. The leg is often twisted or rotated inward below the knee to conform to the position of the foot. When walking begins, the weight is borne on the outer aspect, or dorsum of the foot, which adds pressure to increase and fix the deformity. Walking often causes large bursae to develop on the dorsum of the foot, which may become inflamed and suppurate. There is marked atrophy of the leg in untreated cases.

Symptoms.—The condition is obvious at birth, but produces no symptoms, except the deformity until the child begins to walk. The functional disability is, of course, in proportion to the severity of the deformity. Many patients, however, acquire surprising skill in locomotion, even though the deformity is untreated. Inflammation of bursae and callosities over the abnormal weight-bearing areas is responsible for most of the painful symptoms.

Diagnosis.—The diagnosis at birth requires no differentiation, but later in life there may be a close resemblance to acquired talipes equinovarus, either paralytic or traumatic. In paralytic clubfoot, there is usually a history of normal development at birth and subsequently a definite onset. In children in whom no history is available, differentia-

Fig. 483.—Bilateral congenital clubfoot in infancy.

tion can be made by determination of the muscle power. In congenital equinovarus, there is voluntary action in all muscles, although there may be weakness in the dorsal flexors and peroneal muscles from overstretching, and in the posterior muscles of the calf and tibial group from inactivity. In paralytic equinovarus there is a definite paralysis of the muscles of the foot and leg, and usually evidence of associated paralysis elsewhere in the body. Also in congenital clubfoot the deformity is more frequently bilateral and symmetrical than in paralytic conditions. In traumatic equinovarus there is a history of definite injury of the limb; a muscle or nerve severance, or, rarely, a burn may cause destruction of muscles or nerves with characteristic deformity. In addition, lesions of the central nervous system, as spina bifida, muscular dystrophy, and

progressive muscular atrophy, may cause equinovarus or other distortions of the feet, but differentiation can always be made by the characteristic symptoms of the central lesion.

Prognosis.—The prognosis is excellent if treatment is instituted early. The deformity may recur repeatedly after operative procedures, but correction can be maintained. Recurrence of deformity is so common from inefficient reduction and retention after reduction, that a general impression prevails that correction of this deformity is impossible. The deformity can be corrected, regardless of age, though the earlier this is accomplished, the more nearly perfect will be the restoration of function. In infancy, the foot can be corrected without destruction of tissues, and normal function should be secured in every case; slight

Fig. 484.—Correction of bilateral congenital clubfoot by plaster-of-paris cast. Note window cut to prevent pressure on dorsum of foot.

atrophy of the calf and thigh muscles may persist throughout life, but this, in no way, interferes with the activity of the individual. Growth is not arrested and length is rarely appreciably affected. In middle and late childhood, or at any age after fixed structural changes in the bones have occurred, the foot can be made perfectly straight, so that walking on the sole is permitted, but there is greater arrest in development and appreciable deficiency in length may be apparent. Walking is never normal, the affected foot being of the flat-sole type. There may be a slight limp, but even without an actual limp, the normal resiliency or elasticity in gait is lost. In bilateral equinovarus, the gait is a peculiar waddle, which is quite characteristic.

Treatment.—The treatment depends upon the age of the patient and the resistance of the deformity. In infancy, treatment should always be instituted at the end of two weeks; prior to this time, it may not be convenient to disturb the mother or child, although there is no contraindication to the beginning of treatment on the first day of life. In deformities of mild degree, when no bony anomaly exists, and when the foot may be held straight passively, correction may often be accomplished by simple manipulations. The forefoot is grasped between the fingers of one hand, while the other hand fixes the tiny heel. With the midtarsal region as a fulcrum, the forefoot is turned outward. When varus disappears and the forefoot can be held in the overcorrected position, the forefoot is forced gently in the direction of dorsiflexion. This procedure should be carried out three or four times daily or five or ten minutes for a period of three to six months, or until the foot remains in the normal position and does not reassume the position of equinovarus when relaxed. In addition to the corrective movements, the foot should be held in the overcorrected position by a simple apparatus. In the majority of cases, there is structural deformity of the bones and fixed contractures of the soft tissues, so that full correction can not be obtained by passive movements. These require severer manipulations and more complicated retention apparatus, which may be deferred until the child is one month of age. At this time, two methods may be instituted: (1) Gradual correction by the application of successive plaster casts; and (2) operation or forcible correction under anesthesia. The type of treatment selected depends largely upon the social and financial status of the family. The first method requires about six weeks to two months of constant observation and repeated changes of the casts, and, therefore, may entail considerable expense, if the parents are not living in a vicinity where such treatment can be secured. The second method requires only a few days' observation, after which the mother and child may return to their home to be observed only at intervals of several weeks.

Gradual Correction.—Correction may be accomplished by successive plaster casts in the following manner: the knee is flexed at a right angle, while firm pressure is made to overcome as much varus as possible. A snug bandage of outing cloth, about 2 inches in width, is applied from the toes to the groin, after which a plaster cast is applied. When the plaster has consolidated, the cast is trimmed out over the toes so that the tip of each toe is distinctly visible. The cast should extend on the inner aspect to the tip of the great toe. Once a week, or as often as every five days, a new cast should be applied in the same manner, each

time further correcting the varus of the forefoot. When the varus is well corrected, upward pressure is made on the forefoot to gradually dorsiflex the foot and to stretch the heel cord and the posterior structures of the ankle joint, thus correcting the equinus. When the varus and equinus are both overcorrected and the foot is held in valgus, calcaneus, and dorsiflexion, a cast is applied, to be changed at intervals of one month for a period of two to four months, or until the foot remains in the overcorrected position. At this time, passive motion is instituted, and the foot is placed in a simple retention brace, which is continued until the child is able to walk. When walking is begun, a simple clubfoot brace is applied, which limits plantarflexion and inversion, or in many cases the shoe is simply elevated about $\frac{1}{4}$ inch on the outer aspect. If there is the slightest tendency for relapse of the deformity, retention splints should be worn at night and during rest periods in the daytime. As relapse is apt to occur in congenital clubfoot, the patient should be kept under observation at intervals until at least two years of age.

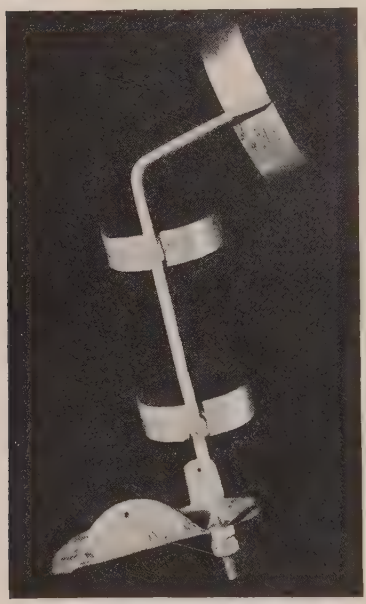


Fig. 485.—Retention splint used for clubfoot after correction by successive casts.

Surgical Treatment.—Correction of equinovarus can be accomplished just as satisfactorily in a much shorter length of time by a very simple operation. The child is anesthetized sufficiently to prevent kicking and to relieve pain; complete narcosis is never required. The foot is grasped with both hands, placing the thumbs over the dorsum of the tarsus. The forefoot is forced into valgus, after which the equinus or plantarflexion is slowly corrected. If the tendo achillis is resistant a subcutaneous tenotomy may be required. A small tenotome is inserted under the skin from without inward, so as to avoid injury to the posterior tibial artery and nerve, and the tendo achillis is severed. When this is accomplished, there is a definite snap and the foot can be dorsiflexed completely. A plaster cast is applied, extending from the toes to the groin, with the knee flexed at a right angle, and the foot in the overcorrected position. Casts extending only to the knee often slip downward,

allowing the foot to assume the original position, and are, therefore, inefficient. Unusual care must be exercised to avoid irritation or necrosis

Fig. 486.—Bilateral congenital clubfoot in child, aged eighteen months.

Fig. 487.—Same as Fig. 486. After correction by manipulation.

Fig. 488.—Congenital clubfoot in child, aged ten years.

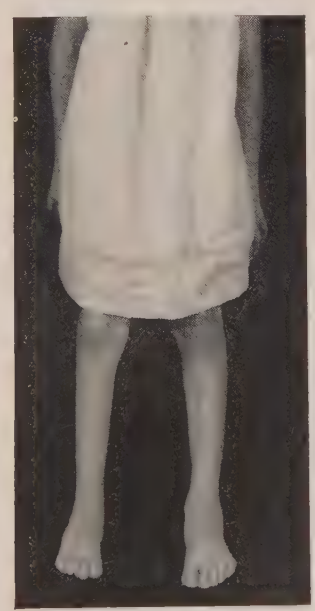


Fig. 489.—Same as Fig. 488. After surgical correction.

from pressure. The color and motion of the toes must be watched carefully for the first twenty-four hours. Paregoric, in doses of 5 to 10

drops may be administered at intervals of about three hours, but if an excessive amount is required, the casts should be bivalved for inspection and reapplied. The casts are changed at monthly intervals for about three months. The after-treatment is the same as when successive casts are employed.

When the child is first examined at one year or older, forcible correction and tenotomy are indicated. A wedge-shaped wooden block, as advocated by Lorenz, or the Thomas wrench, which is a modification of the ordinary monkey-wrench, is required to force the foot from varus to valgus. The subsequent treatment is similar to that heretofore described, except that longer intervals may elapse before the casts are

Fig. 490.—Congenital clubfoot in adult.

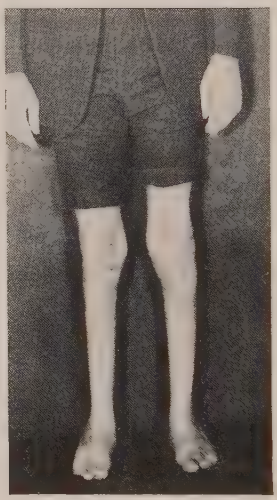


Fig. 491.—Same as Fig. 490. After surgical correction.

changed. Passive movements of the feet are employed by the mother when the casts are discarded. In older children, from five to ten years of age, correction may be accomplished frequently by forcible manipulations under anesthesia. In the relapsed and more severe deformities and in adults, open operative procedures are required to correct the varus; the tarsal bones must be reconstructed, especially those in the subastragalar region. The tendo achillis and posterior capsule of the ankle joint are lengthened by plastic procedures and the equinus and plantarflexion are corrected. After operation, the foot is retained in the corrected position by a plaster cast for a period of eight weeks. A simple clubfoot brace is then applied to be worn for six months, the outer aspect of the sole of the shoe being elevated. After the deformity of the

foot is corrected by any method, there may be pronounced intoeing when walking, which is caused by the inward rotation of the leg. This may often be corrected by education, but if persistent, an osteotomy of the tibia in the upper third should be done; the fibula can be manually fractured and the leg rotated outward, placing the foot and knee in normal relation.

TALIPES VARUS

Simple varus of the forefoot without equinus is rare. The anterior part of the foot turns inward. The treatment is similar to that described for clubfoot, except that it is not necessary to divide the tendo achillis. The deformity is unusually resistant to treatment and requires very close observation for at least two years after treatment is discontinued.

TALIPES VALGUS AND TALIPES CALCANEOVALGUS
(Congenital Flatfoot)

Talipes valgus or congenital flatfoot is of very common occurrence. In exaggerated cases, at birth, the dorsum of the foot approximates the leg, but the foot can usually be held passively in the normal position. Structural osseous changes are rarely observed. In those in whom the anterior group of muscles of the leg and the peroneal muscles are contracted, correction can be accomplished by successive plaster casts. In a majority, this deformity can be corrected by a simple splint made of galvanized iron or aluminum to conform to the sole of the foot and the inner aspect of the leg. The foot and leg are held to the splint by simple bandages with the foot adducted. The mother is taught to plantarflex and adduct the foot passively three or four times a day. Correction is usually accomplished in a few months, and there is no tendency to recurrence. When the child begins to walk, routine treatment for flatfoot or pes planus may be required, described in the chapter on Static Deformities.

TALIPES EQUINUS

Congenital talipes equinus is a rare anomaly, in which the heel cord and the posterior structure of the leg are contracted, holding the foot in plantarflexion. The arch of the foot is abnormally elevated into cavus, and when walking is instituted, the weight is borne on the ball of the foot. Unless corrected early, the affected extremity is extensively shortened. In infancy, correction may be accomplished by successive casts gradually forcing the foot into dorsiflexion, as in the second stage of the treatment for equinovarus. Also, the tendo achillis may be severed by subcutaneous tenotomy, after which a cast is applied holding the foot

in dorsiflexion. In older children the tendo achillis should be lengthened by the Z-shaped plastic method, as there is a possibility of extensive retraction with loss of power to the posterior group of muscles. If the longitudinal arch of the foot is too high and cavus exists, the contracted structures on the sole of the foot must be severed; this can usually be accomplished subcutaneously. The after-treatment is based on the same principles as that for congenital clubfoot.

GENU RECURVATUM

Genu recurvatum, or congenital hyperextension of the knee, is caused by imperfect development of the quadriceps muscle and may be associated with rudimentary development or absence of the patella. The leg bends forward instead of backward at the knee joint. There may also be a forward displacement of the tibia on the femur. Correction of the deformity may often be obtained in infancy by gradual flexion of the knee, using a malleable posterior splint of sheet metal. The knee is flexed as much as possible and the splint applied. At weekly intervals, the knee is further flexed and the splint bent to conform to the corrected position until the knee is held at 90 degrees flexion for one month, or longer, if there is a tendency for recurrence. This simple measure will often correct a very disabling deformity. For older children, in whom the anterior structures composing the quadriceps muscle are materially shortened, and in those with associated dislocation of the tibia, the deformity may be resistant. Operative procedures are indicated when the child is about two years of age to lengthen the contracted structure. Prolonged immobilization and support by braces are required after the operation, as well as massage and exercises, to develop the weakened muscles.

Fig. 492.—Congenital dislocation of knee.

DISLOCATION OF THE HIP

Congenital dislocation of the hip is frequently observed. The usual displacement is a dislocation of the head of the femur upward and back-

ward on the dorsum of the ilium. The dislocation occurs more frequently in girls than boys and may be single or double. As in other congenital anomalies, there is much speculation as to the origin. Increased flexion in utero, a purely mechanical condition and developmental malformation, of which there is often evidence from the association with other congenital deformities, are regarded as the probable causes. The statement that injury at birth may produce congenital dislocation of the hips is untrue or, at least, of exceedingly rare occurrence. Fracture of the femur or pelvis would ensue before the hip would dislocate. As in other congenital anomalies, there is a familial tendency and dislocation of the hip may occur in succeeding generations, or in several members of the same family.

Pathology.—The head of the femur is displaced from the acetabulum and is irregular in shape, being often conical instead of globular. The neck is shortened, twisted, and coxa vara is common. The torsion of the neck of the femur is usually in an anterior direction, so that the head lies on a plane anterior to the normal position. The acetabulum is shallow, flat, and triangular in shape and is filled with cartilage and fibrous tissue to a greater or less degree. The rim of the acetabulum is deficient above and posteriorly. The capsular ligament is contracted about the acetabulum and the head of the femur, with a constriction between the head and the acetabulum, forming the so-called hour-glass contraction. When dislocation is of long standing, a shallow false acetabulum, with which the head of the femur articulates, is formed on the ilium. This new joint may remain intact for some time, but the head of the femur gradually slips out of position and another false acetabulum is formed. This process may be repeated several times. Rarely, a deep socket is formed on the ilium and the patient in this manner develops a functional joint, and might be said to make a partial spontaneous recovery.

Fig. 493.—Congenital dislocation of hip, illustrating lengthening of ligamentum teres and hour-glass contraction of joint capsule.

Symptoms.—The clinical manifestations are usually not detected

until the child begins to walk, when a slight limp is noticed. The gait becomes progressively more abnormal, the limp being peculiarly elastic

Fig. 494.—Congenital dislocation of left hip, showing deficiency of rim of acetabulum.

Fig. 495.—Same as Fig. 494, after reduction and fixation for eight months.

as the trochanter ascends when weight is placed upon the dislocated hip. In early childhood, no pain or local tenderness is present, and passive and active motions are increased in all directions. The trochanter

is higher than normal, as indicated by its relation to Nélaton's line, and, on palpation over the center of Poupart's ligament directly over the femoral artery, a definite lack of resistance can be detected as compared to the normal side. The symptoms differ somewhat in single and double dislocations. In unilateral luxation a definite decrease in length of the affected limb will be demonstrated on mensuration. The gait is characterized by a lurch of the body toward the affected side. In bilateral dislocations, there is a peculiar elastic waddle when the child first begins to walk. This becomes more exaggerated as age advances and is so unusual as to be a source of derision from others and a pathetic

Fig. 496.—Bilateral congenital dislocation of hips, showing plaster-of-paris cast from pelvis to below knees. Lorenz position.

embarrassment to the patient. The width of the perineum is increased. As both hips are posterior to their normal position, there is a compensatory lordosis in the lumbar spine—a definite swayback. The other manifestations are similar to those of single dislocation. With increase in body weight, the trochanter, with the head and neck of the femur, ascends, making the limp more apparent in bilateral dislocation and the difference in length of the two limbs greater in unilateral cases. Symptoms of pain and disability also appear, as there is no support for the upper extremity of the femur, except the muscles and fibrous tissue. In rare instances, a new acetabulum may be developed on the dorsum of

the ilium which affords partial support; a degree of disability is always present, though in some it may be mild.

Diagnosis.—The diagnosis can be made by the symptoms, but should be confirmed by the roentgenogram which demonstrates the anatomical abnormality; the head of the femur is dislocated, the contour of the head and neck is anomalous, and the acetabulum is flattened. There is no evidence of a destructive process. Paralytic dislocation may resemble congenital dislocation, but the neck of the femur shows pronounced atrophy with coxa valga and there is an associated muscular paralysis. Traumatic dislocations are preceded by injury and the roent-

Fig. 497.—Showing bilateral dislocation of hips.

Fig. 498.—Same as Fig. 497. Lateral view. Note extreme lordosis.

gen ray demonstrates the formation of the bones to be normal, although the head of the femur is displaced from the acetabulum. Adduction contracture with limited motion in the hip joint is also usually present in unreduced traumatic dislocations. The only condition which may present almost identical symptoms is a dislocation of the hip following acute infectious arthritis, or some low-grade painless process, as syphilis. In these conditions differentiation is made by the roentgenogram, which shows marked destructive changes in the roof of the acetabulum. The upper margin may have entirely disappeared, permitting the hip to

ascend from the pressure of weight-bearing. Such affections, as tuberculosis of the hip, coxa vara, and infectious arthritis, present significant subjective and objective symptoms which are distinctive of the individual lesions.

Prognosis.—The prognosis depends upon the age at which the diagnosis is made and the reduction attempted. If reduction is accomplished in early life, without undue trauma, a stable hip joint, with normal function, may be expected. The preferable age for reduction has been

Fig. 499.—Untreated bilateral dislocation of hips in adult.

Fig. 500.—Same as Fig. 499. Note positive Trendelenburg sign.

considered to be from two to four years. In recent years there is a tendency toward reduction as soon as the diagnosis is made. Anatomical reduction with good function may be secured as late as eight or ten years, or older, but the percentage of success is far less than in early childhood. As age advances, the head, the neck of the femur, and the acetabulum become more abnormal and reduction is increasingly difficult. If treatment is not instituted before adolescence, the possibility of securing good function, even after reduction, is diminished. It is, therefore, obvious that an early diagnosis is of the utmost importance. The attending physician should make these conditions plain to the parents

and urge proper procedures at the most propitious time. In single dislocation, the prognosis is, of course, better than in the bilateral form.

Treatment.—Reduction may be accomplished by manipulation or by operative procedure. The method chosen depends upon the age of the patient, the peculiarities of the individual case and the skill of the operator.

Manipulation.—The technic of the manipulative or bloodless method has been developed by Lorenz, Calot, Hibbs, Davis, and others. The general principles of each method are similar and consist of a preliminary stretching of the contracted muscles and ligaments, the manipulative maneuvers, and the retention of the joint after reduction is accomplished. Complete anesthesia is required. The pelvis is immobilized by special apparatus or by an assistant who flexes the opposite thigh upon the abdomen. The adductor muscles and other contracted structures are loosened by kneading, massage, traction, and circumduction of the hip. The knee and hip are flexed to 90 degrees, the thigh is abducted and upward pressure made over the head of the femur by the surgeon's thumbs, or a small wooden wedge applied against the trochanter may be used as a fulcrum. When the manipulation is successful, the head of the femur slips into the acetabulum with an audible snap. The head is easily redislocated when the position of the limb is changed by extending and adducting the thigh, there is usually an audible snap when the redislocation occurs, but this is not so loud as that accompanying the reduction. Secondary replacement of the head into the acetabulum is usually accomplished with less effort than that required in the primary manipulation. The head can be felt in the normal anatomical position beneath the femoral artery when the reduction is accomplished, and the hamstring muscles are taut, holding the knee in the flexed position, making complete extension of the knee impossible. After reduction, the hip is placed in a plaster-of-paris spica cast in that position in which reduction can be maintained most effectively. The position of full abduction, flexion, and external rotation of the hip, with the knee flexed at 90 degrees is usually employed. Lange has suggested the position of hyperextension, abduction, and internal rotation for those cases which are difficult to hold in the usual manner. The relation of the head of the femur to the acetabulum should be checked by the roentgenogram before and after the application of the cast. The cast is changed at the end of two months, at which time the roentgenological examination is repeated. A sufficient length of time is allowed to elapse before the cast is removed, for the development of the ace-

tabulum to such an extent that the head will be retained. This usually requires from six to eight months. Active use is then encouraged with gradual resumption of weight-bearing; physiotherapy is often a valuable adjuvant in the restoration of function.

Surgical Treatment.—In older children, above the age of eight, and in some instances below this age, depending upon the development of the individual, manual reduction may rarely be accomplished without undue trauma. If great force is necessary, open operation is preferable. Galloway believes that in single dislocation open operation is indicated at practically any age. The joint may be exposed by either an anterior or posterior incision. In young children the anterior incision affords the best approach to the joint, and is made in the long axis of the limb, extending downward for 4 inches from the anterior superior spine; the upper part of the incision is extended backward along the crest of the ilium; the muscles are separated from the ilium and retracted, exposing the joint capsule, which is incised transversely. If the capsule is found to be constricted, the narrowed portion is freely divided. The head of the femur may then be reduced using a bone-skid or other instrument for a guide. The wound is closed and the limb immobilized in a plaster-of-paris cast in that position in which reduction is most stable. In older patients, or in any case in which exceptional difficulty is anticipated, the posterior incision may offer certain advantages. A Kocher incision, from 5 to 8 inches in length, is made, the upper part extending from the upper border of the trochanter parallel to the fibers of the gluteus maximus muscles, and the lower half following the long axis of the limb along the outer side of the femur. The muscles are separated from the greater trochanter and the capsule is exposed and incised along the upper border of the head and neck of the femur. The constricting portion of the capsule is divided and the acetabulum, if shallow or filled with fibrous tissue, is deepened with a curet. The dislocation is reduced and the limb immobilized in a plaster-of-paris cast.

In many, even by open operation, reduction may be accomplished only by excessive tension on the soft tissues, and under such circumstances should not be attempted. When the diagnosis is made late and reduction is not possible, much relief of pain and disability, as well as improvement in function, may be secured by an operation to form a new acetabulum on the dorsum of the ilium on a line with the normal acetabulum. This procedure may be carried out in adults as well as in older children. When the neck of the femur is severely rotated, reduction may be accomplished only by maintaining the limb in extreme inward rotation. If this inward rotation is of sufficient degree to in-

terfere with function of the limb, an osteotomy of the femur with outward rotation of the lower fragment should be performed to correct the deformity.

CONGENITAL ANOMALIES OF THE SPINE

Congenital anomalies of the spine, as deficiencies in the number of the vertebrae, supernumerary vertebrae, partial supernumerary vertebrae, and hypertrophy of normal processes are not uncommon. Variations are prone to occur about the junction of the different regions of the spine. Spinal anomalies may be associated with fusion of one or more ribs; there may be six instead of five lumbar vertebrae. The transverse processes of the fifth lumbar vertebrae may be enlarged and encroach upon the wing of the sacrum, and may cause symptoms in later life. Spina bifida, due to lack of fusion of the spinous processes, may be associated with a meningocele and has been described in the section on Affections of the Nervous System.

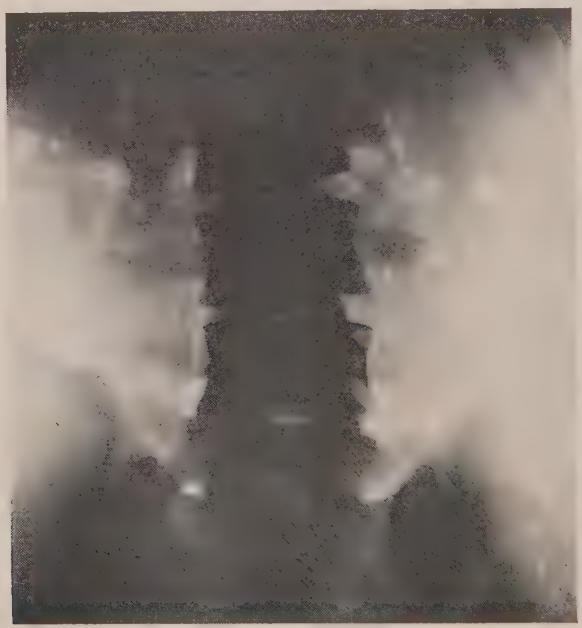


Fig. 501.—Bifurcation and sacralization of transverse process of fifth lumbar vertebra.

CERVICAL RIBS

Anomalous development of the vertebral and costal units of the skeleton is more common at the junction of the various regions of the spine. Supernumerary ribs may occur, attached to the seventh cervical

or first lumbar vertebrae. In the lumbar region, the extra rib causes no symptoms. In the cervical region four types may be distinguished: (1) A rudimentary structure represented by a tubercle projecting from the transverse process; (2) a rudimentary rib about 1 inch long; (3) a rib 3 or 4 inches in length, articulating with the first thoracic rib or connected with the sternum by a ligament; (4) a complete rib articulating with the sternum. The condition may be unilateral or bilateral, but is rarely symmetrical on the two sides.

Symptoms.—The symptoms which are not usually apparent until early adult life are caused by compression of the brachial nerves and the subclavian vessels. The patient complains of numbness and tingling in the arm and forearm, the distribution being commonly confined to the area supplied by the ulnar nerve. Later the sensation becomes a

Fig. 502.—Cervical ribs.

boring pain, the muscles are weakened and atrophic, and anesthesia develops. The artery is compressed to a greater extent than the veins, and, consequently, the vascular symptoms are those of anemia rather than congestion. The arm is pale, its surface cold and the brachial and radial pulses diminished. There may be edema of the extremity, vasomotor flushing, and excessive sweating. Blood pressure readings in the two arms may show a distinct variation. The symptoms are aggravated by functional use and by allowing the arm to hang at the side, but are relieved by elevating the arm over the head. Endarteritis followed by thrombosis and gangrene may occur. Trophic disturbance may cause a glossy appearance of the skin and the formation of blebs. The fingernails may become roughened and brittle and there may be hemorrhages beneath the nails. Occasionally, the sympathetic nerves

are involved, giving rise to pupillary inequality, ptosis, and retraction or protrusion of the eye. The phrenic nerve and the recurrent nerve have been affected, involvement of the latter causing hoarseness and aphonia. A bony mass may be palpable in the posterior triangle of the neck immediately above the clavicle, and the artery may be felt pulsating over the tumor. The roentgenogram demonstrates the rib. The symptoms may be severe in cases in which the costal segment itself is small, the pressure being caused by the fibrous prolongation from the rib to the sternum or first thoracic rib.

Diagnosis.—The diagnosis is often made accidentally by the roentgenogram when pressure symptoms are not evident. Tingling, anesthesia, muscular paralysis and coldness of the upper extremity are highly suggestive and when present should always indicate a roentgenological examination of the cervical spine. Congenital variations in the brachial plexus may, however, cause similar symptoms when the skeletal development is normal, the pressure is such cases being exerted by the first thoracic rib.

Treatment.—The accidental finding of a cervical rib is of no significance unless pressure symptoms are in evidence. In the milder cases conservative treatment is advisable. Rest, avoidance of strain, and weight-carrying, and the thorough support of the arm by a properly arranged sling all tend to avoid irritation of the nerves and vessels by rib contact. Electricity, massage, applications of heat and cold, and general measures, such as are commonly indicated in brachial neuritis, have a definite place in the management of these cases, but the severer ones give rise to so much pain and inconvenience as to be almost insupportable.

Surgical Treatment.—In cases of the more pronounced type, resection of the rib is the only means of relief. The operation may be performed through an anterior or a posterior incision. For the anterior approach, an incision is made, beginning over the insertion of the sternomastoid muscle and carried upward and outward to the edge of the trapezius muscle, bisecting the angle between the sternomastoid muscle and the clavicle. After the platysma and superficial fascia have been divided, a double ligature is placed about the external jugular vein and the vessel divided. The deep cervical fascia is divided, the subclavian vessels and the brachial plexus exposed by blunt dissection. The soft tissues are separated carefully from the rib, keeping the dissection subperiosteal, if possible. The rib is traced to its spinal origin and there divided with bone cutting forceps. The anterior extremity is then divided, the rib removed, and the wound closed.

The posterior incision, as advocated by Streissler, begins $\frac{3}{4}$ inch lateral to the spinous processes and a handbreadth above the spine of the seventh cervical vertebra. The fibers of the trapezius, both rhomboid muscles, the serratus posticus, and the splenius are divided. The fibers of the complexus and the semispinalis colli are separated, exposing the transverse process of the lower two cervical and the upper two thoracic vertebrae. The transverse process of the seventh cervical vertebra is removed with bone forceps, which brings the supernumerary rib into view. A curved periosteal elevator, or other guard, is passed about the neck of the rib to protect the nerve roots which lie just anterior to it, and the rib divided. The bone is dissected carefully from the surrounding structures, as far forward as possible and removed. An anterior incision to expose and detach the anterior extremity is sometimes necessary.

ELEVATION OF THE SCAPULA

(Sprengel's Deformity)

The scapula may be elevated above its normal position with shortening and alteration in the direction of the scapular muscles; the elevated position fixes the bone and limits abduction of the shoulder. The condition is believed to be the result of malposition in utero which prevents the normal descent of the shoulder girdle. It may be bilateral and may be associated with other congenital abnormalities of the spine and extremities.

Symptoms.—In addition to the elevation, the scapula is rotated about its anteroposterior axis, so that its vertebral border, instead of being parallel to the spinous processes, is closer to the midline at the upper angle than at the lower angle. The clavicle is frequently shortened and the upper angle of the scapula forms a prominent projection at the back of the neck. Abduction of the arm is limited, the chest is poorly developed, and in some cases, scoliosis, torticollis, and asymmetry of the face may be associated. The disability, while slight in childhood, becomes more pronounced after puberty when increased functional activity is assumed.

Treatment.—Active and passive movements of the arm, with exercises and massage, constitute the conservative treatment. Operative dissection of the scapula from its muscular attachments may succeed in releasing the contracture and depressing the bone. Prolonged immobilization in a plaster cast is necessary but perfect reduction is rarely if ever obtained, although improvement often results from the operation.

TORTICOLLIS
(Wryneck)

Torticollis is caused by contracture of the sternocleidomastoid muscle and may be congenital or acquired in origin. The acquired type may be a manifestation of such conditions as tuberculosis and pyogenic infection of the cervical glands. The congenital type, like other congenital deformities, is caused by errors in development or abnormal position in utero. Myositis of the sternocleidomastoid muscle from birth injury with hematoma may cause torticollis, which, in reality, is not congenital, but acquired.

Fig. 503.—Congenital torticollis.

Fig. 504.—Same as Fig. 503. After correction.

Symptoms and Diagnosis.—In congenital torticollis, the head deviates at birth toward the side of the contracted muscle and the chin toward the opposite side. The muscle alone may be contracted, but not infrequently there is an associated structural deformity in the cervical vertebrae and also other congenital anomalies. When torticollis is of long standing, there is an asymmetrical development of the face. The side on which the sternomastoid muscle is contracted is usually atrophied, the degree of atrophy being increased in proportion to the duration of the deformity. The diagnosis of torticollis is made from the history and clinical manifestations; differentiation of the congenital from the acquired type is often necessary in those in whom there is no available history. In tuberculosis of the cervical vertebrae, all the muscles of the neck are in a state of spasm and there are other local symptoms. If of long duration, the roentgenogram will define the

tuberculous process. Traumatic torticollis, or an infectious process of the neck, as in tuberculosis of the cervical glands, presents definite local symptoms and manifestations. In ocular or aural affections, with defective vision and hearing, the head may be held to one side, but can usually be straightened voluntarily. Hysterical torticollis is not uncommon, but can usually be differentiated by the nervous status of the child; correction may be obtained by force or under anesthesia.

Treatment.—The treatment of congenital torticollis should be instituted on the day of birth if possible. The head is manipulated against contracture of the sternomastoid muscle; for example, if the right sternomastoid muscle is contracted, the occiput and chin are grasped with the hands and the chin rotated to the right and the occiput to the left. This procedure is repeated three or four times daily for a period of three to five months, gradually increasing the time of manipulation at each treatment. In bed, no pillow should be used, and the infant is placed on the side to which the occiput rotates; an ordinary brick, suitably covered and placed against the occiput on the side to which the occiput deviates will hold the head partially straight when the infant is on its back. By these simple means, correction in a large percentage can be secured during the first year. When the deformity is of longer duration, in older children and in adults, an operation with efficient after-treatment is required. An incision is made at the insertion of the sternomastoid muscle parallel with the clavicle, this muscle and the platysma muscle are divided, and the head manipulated into the overcorrected position. A plaster cast or other apparatus is applied to maintain the corrected position for several weeks. After the apparatus has been discarded, head traction at night and manipulation of the head and neck should be continued for some time. When correction is obtained in early childhood asymmetry of the face disappears entirely, and improves to a marked degree when made later. Should structural deformity and congenital anomalies exist, full correction may be impossible, but with efficient treatment, marked improvement may be expected in the majority of cases.

MADELUNG'S DEFORMITY

A spontaneous subluxation of the wrist which develops usually about the age of puberty is known as Madelung's deformity. The condition is not a true congenital abnormality, but is probably due to some nutritional disorder or to occupational strain. The lower extremity of the radius is bent or curved forward and the head of the ulna is displaced backward. Pressure on the ulna reduces it to the level of the

radius, but relapse occurs immediately on releasing the pressure, due to laxity of the lower radio-ulnar ligaments. The condition is usually bilateral. The wrist is weakened and the disability is progressive. The appearance is unsightly and should always be corrected. The treatment

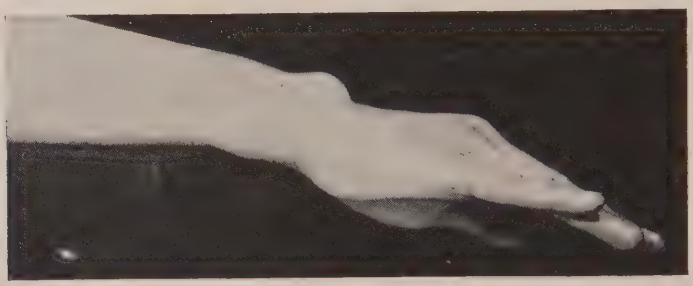


Fig. 505.—Madelung's deformity.

consists of an osteotomy of the lower extremity of the radius; the articular surface of the radius is rotated backward to the normal position and the correction maintained by a plaster cast.

CONGENITAL FIBROUS ANKYLOSIS

(Arthrogryposis Multiplex Congenita)

Arthrogryposis multiplex congenita is an incomplete fibrous ankylosis of several or all of the joints and is rarely observed. The condition is congenital, and the cause, as suggested by Stern, is probably prolonged intra-uterine pressure. The deformities are due to thickening and contracture of the periarticular tissues and not to muscular or tendon contraction. The disease, as far as is known, is not hereditary. The principal characteristics are limitation of motion in the joints, and a rotary deformity of the upper and lower extremities; the arms are twisted inward, the thighs and legs outward. The knees and elbows are usually extended, the hands and feet clubbed and the joints present a typical fusiform or cylindrical shape. The tibia may be rotated on the femur so that the joint surfaces do not articulate normally, and motion is mechanically blocked or limited. Often several degrees of movement may be present, but the motion is from side to side instead of anteroposteriorly. Absence of the patella and other congenital anomalies, as dislocation of the hips, are often associated. Physiotherapy may be of great benefit in increasing the range of motion in the joints if instituted early in infancy. Massage, passive movements, and gradual correction of the deformities of the hands, elbows, feet and knees, by splints and plaster casts, may be done during the first year of life. In later child-

Fig. 506.—Congenital fibrous ankylosis of all joints.

hood surgery is the only treatment from which relative improvement may be expected.

SYNDACTYLISM

Syndactylism, webbed fingers, and webbed toes are hereditary anomalies in which two or more digits of the hand or foot are bound

Fig. 507.—Congenital absence of fourth and fifth fingers and syndactylism of the second and third fingers.

together. The union may consist of skin alone, skin and fibrous tissue, or there may be fusion of the bones to a greater or less degree. The condition is probably the result of arrested development since the phalanges are united normally for a time during fetal life. The symptoms in mild cases arise only from the cosmetic defect. When, however, several fingers are involved, there may be serious impairment in function of the hand. The treatment is entirely surgical. Many ingenious operations have been devised for the details of which the reader is referred to works on general and plastic surgery.

BIBLIOGRAPHY

Calot, F.: Traitement de la luxation congenitale de la hanche, Gaz. méd. de Par., 2 : 423 (ser. 9), 1895.

Campbell, Willis C.: Congenital Hypertrophy, Surg., Gynec. and Obst., 36 : 699, 1923.

Davis, G. G.: A Case of Double Dislocation of the Hip Replaced by Manipulation, Arch. Pediat., 18 : 380, 1900.

Galloway, H. P. H.: The Open Operation for Congenital Dislocation of the Hip, Jour. Orthop. Surg., 2 : 390, 1920.

Hibbs, R. A.: An Original Method of Operating for Congenital Dislocation of the Hip, New York Med. Jour., 87 : 767, 1908.

Lange, F.: Behandlung der angeborenen Huftuerrenkung, München med. Wchnschr., 45 : 451, 491, 1898.

Lorenz, A.: Pathologie und Therapie der angebornen Hüftuerren Kung, auf Grundlage von hundeit operatio behandelten, Fällon, Wien., 1895.

Stern, Walter G.: Arthrogryposis Multiplex Congenita, Trans. Amer. Med. Assoc. (Orthopedic Sec.), 1923, p. 66.

Streissler, E.: Eine neue Methode der Resektion der Halsrippen von rückwarts, Zentrahbl. f. Chir., 39 : 283, 1912.

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